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A RECONNAISSANCE OF THE WATER RESOURCES IN THE PORTNEUF RIVER BASIN, IDAHO

by

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ABSTRACT

The part of the Portneuf River basin described includes an area of about 1,160 square miles in southeastern Idaho. It lies on the Columbia River side of the divide between the Columbia River basin and the Great Basin drainages.

The average annual water supply of the basin is estimated to be slightly more than 1.2 million acre–feet. Precipitation on the basin contributes about 1.2 million acre–feet, importation of water from the adjacent Bear River basin contributes about 0.014 million acre–feet and an unknown amount is contributed by underflow from the Bear River basin.

The major aquifers in the basin are the Salt Lake Formation of Tertiary age and the alluvium and basalt of Quaternary age. Recent geophysical work suggests that the central part of Gem and Portneuf Valleys, on the eastern side of the basin, is a structural trough (graben) that may contain as much as 8,000 feet of sediments. These sedimentary deposits may contain a tremendous volume of ground water in storage.

The major use of water is for irrigation. About 13,500 acres are irrigated with ground water. Gross pumpage is about 30,000 acre–feet per irrigation season and the average consumptive irrigation requirement is about 1.1 acre–feet per acre. Thus, annual net pumpage for irrigation is about 14,800 acre–feet. There is no evidence to date that the aquifers are being over–developed by pumping.

Roughly 91,300 acre–feet of surface water is distributed annually to irrigate about 20,000 acres of land.

An apparent loss in streamflow from Portneuf River and Marsh Creek of about 87 cubic feet per second (63,000 acre–feet per year) occurs somewhere between the gaging stations at Topaz and McCammon and the gaging station at Pocatello which is out of the area of study. Probably the Portneuf River is perched above the water table, at least in the reach from Inkom to the Portneuf Gap and some distance beyond, thus facilitating this loss.

Major items on which future work should focus for a more comprehensive water–resources evaluation of the basin are: (1) water budget, (2) hydrologic mapping, (3) hydrology of aquifers, (4) irrigation system, (5) geologic mapping, and (6) special problems.

INTRODUCTION

This report presents the results of a reconnaissance of the water resources in the part of the Portneuf River basin that lies upstream from the Portneuf Gap. The area of study includes about 1,160 square miles, and, except for a small area in Gem Valley, is bounded by surface–drainage divides in the surrounding highlands, figure 1. Because both the surface– and ground–water divides across Gem Valley are somewhat nebulous, the boundary in the valley was drawn on the hydrologic–areas boundary adopted by the Idaho Department of Reclamation. The southeastern boundary of the area lies along the divide between the Columbia River basin and the Great Basin. The area, as described above, will subsequently be referred to in this report as "the Portneuf River basin" or "the basin".

Purpose and Scope

This hydrologic reconnaissance of the Portneuf River basin was made by the U.S. Geological Survey in cooperation with the Idaho Department of Reclamation. It is part of an overall program to evaluate the water resources in the State so that an orderly optimum development of those resources can be attained.

The primary purpose of this report is to present and discuss the hydrologic data collected during this reconnaissance. In addition, hydrologic problems that have resulted from use of the water resources are pointed out, and the scope required of some future project aimed at describing more fully the water resources of the basin is presented.

The work accomplished during this reconnaissance, made in the period July 1968 to June 1969, consisted of (1) a partial inventory of water wells in the basin; (2) establishment of new stream–gaging sites and ground–water observation wells; (3) geologic and hydrologic mapping; (4) mapping of areas irrigated with ground water; (5) an evaluation of the use of ground and surface water for irrigation; (6) an evaluation of the interrelation between surface and ground water; (7) a generalized appraisal of the chemical quality of the water resources; and (8) an evaluation of the need for and the possible methods that could be used to make a comprehensive quantitative study of the water resources of the basin.

Previous Studies

No overall geologic or hydrologic study of the Portneuf River basin has been made although parts of the geology and some facets of the hydrology have been included in reports of other areas. The earliest geologic mapping was done in the northern and northeastern part of the basin by Mansfield (Mansfield and Heroy, 1920; Mansfield, 1929, 1952) who reported on the geography, geology, and mineral resources of the Fort Hall Indian Reservation. Later geologic works consisted of local studies that described the geologic formations and structure of highland areas in the basin. The limits of, and references to, those studies are shown on the generalized geologic map (fig. 5). The generalized geology of the entire basin is shown on the State geologic map (Ross and Forrester, 1947).

Early hydrologic work in the area consisted of streamflow measurements made at different times in the Portneuf River and in Topance and Pebble Creeks during the period 1910–15. The records of those measurements and later streamflow measurements made through September 1950 are contained in Water–Supply Paper 1317 (U.S. Geological Survey, 1956). Subsequent streamflow records are contained in Water–Supply Paper 1737 (U.S. Geological Survey, 1963) and in an annual series of reports titled Water Resources Data for Idaho.

Heroy (Mansfield and Heroy, 1920) briefly described the surface–drainage system of the basin in an early study of the water resources of the Fort Hall Indian Reservation. Fragmentary information on the irrigation system in the basin is contained in Water–Supply Paper 657 (Hoyt, 1935) which is an early report on water use in the Snake River basin. Stearns and others (1938) gave brief geologic and hydrologic descriptions of parts of the Portneuf River basin in a report on the Snake River in southeastern Idaho. Plate 19 of that report shows contours on the water table (for 1928–29) in the upper Portneuf Valley and along Marsh Creek from Virginia northward. Mundorff and others (1964, p. 44, 94), in describing the hydrology of subareas of the Snake River basin, include estimates of water yield for the parts of the Portneuf River basin above Topaz and above Pocatello. An early reconnaissance study by Twiss (1939) of the Marsh Creek valley from Red Rock Pass to about a mile north of McCammon briefly described the geology and ground–water resources in that part of the basin. Twiss included a generalized geologic map, a water–table contour map, and a map briefly categorizing water conditions in the valley.

Other reports that discuss topics related to the geology and water resources of the basin include a geographic study of Marsh Creek valley by Strawn (1964), a soil survey of a large part of the basin by Lewis and Peterson (1921), a preliminary report on the Portneuf–Marsh Valley Canal Project by Woodward (1956), and a reconnaissance report of erosion and sedimentation in the basin by Merrell and Onstott (1965).

In addition to the above reports, the U.S. Army Corps of Engineers has made flood–control project studies near Inkom and Lava Hot Springs. Some preliminary unpublished data on the results of that work were available for use in study.

Acknowledgments

Many farmers in the area cooperated fully in offering information about their irrigation practices and in allowing water–level measurements to be made in their wells. Operators of small businesses also cooperated in providing well data. Municipal officials and employees were helpful in providing information on town water–supply systems. Officials of the Utah Power and Light Company, Preston, Idaho, and the Idaho Portland Cement Company, Inkom, Idaho, were very helpful in offering data for use in this study. To all of the above, the authors are grateful.

Numbering System

The numbering system used in Idaho by the U.S. Geological Survey indicates the location of a well or spring in the official rectangular subdivisions of the public lands (fig. 2). The first two segments of the number designate the township and range. The third segment gives the section number and is followed by three letters and a numeral, which indicate, respectively, the quarter section, the 40–acre tract, the 10–acre tract, and the serial number of the well or spring within the tract. Quarter sections are lettered a, b, c, and d in a counterclockwise order from the northeast quarter of each section. Within the quarter sections, 40–acre and 10–acre tracts are lettered in the same manner. Thus well 7S–38E–13ddb1 is in the NW¼SE¼SE¼ sec. 13, T. 7 S., R 38 E., and is the first well visited in that 10–acre tract.

Use of Metric Units

In this report, the units that indicate concentrations of dissolved solids and individual ions determined by chemical analysis and the temperatures of air and water are metric units. This change from reporting in "English units" has been made as a part of a gradual change to the metric system that is underway within the scientific community and is intended to promote greater uniformity in reporting of data. Chemical data for concentrations are reported in milligrams per liter (mg/l) rather than in parts per million, the units used in earlier reports of the U.S. Geological Survey. For concentrations less than 7,000 mg/l, the number reported is about the same as for concentrations in parts per million. Air and water temperatures are reported as degrees Celsius (°C).

The following table will help to clarify the relation between degrees Fahrenheit and degrees Celsius.

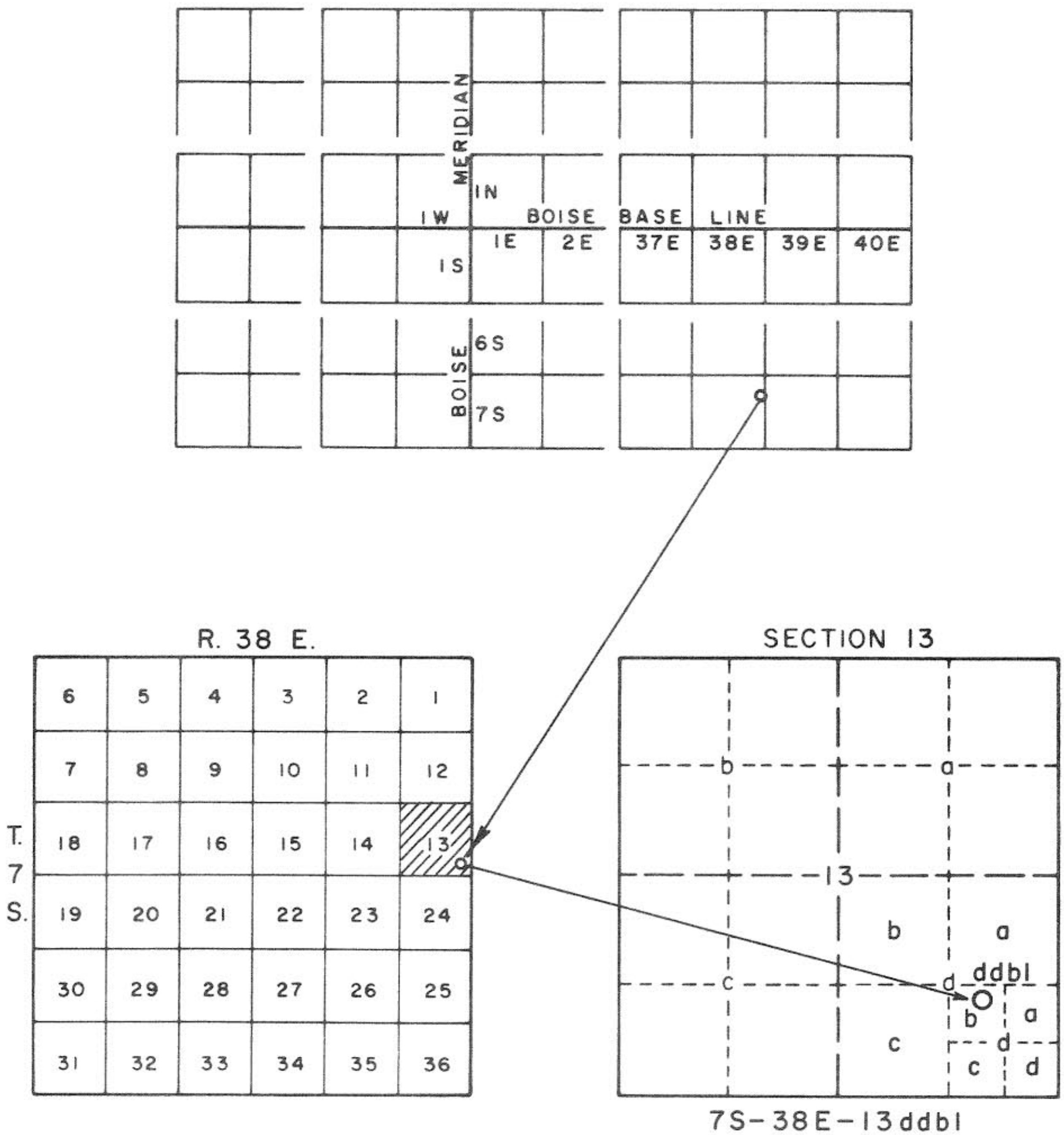

FIGURE 2.-- Diagram showing the well-numbering system.
(Using well 7S-38E-13ddbl).

TEMPERATURE–CONVERSION TABLE

For conversion of temperature in degrees Celsius (°C) to degrees Fahrenheit (°F). Conversions are based on the equation, $°F = 1.8°C + 32$. Temperatures in °F are rounded to nearest degree. Underscored equivalent temperatures are exact equivalents. For temperature conversions beyond the limits of the table, use the equation given, and for converting from °F to °C, use $°C = 0.5556 (°F – 32)$. The equations say, in effect, that from the freezing point (0°C, 32°F) the temperature rises (or falls) 5 °C for every rise (or fall) of 9 °F.

°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
-20	-4	-10	14	0	32	10	50	20	68	30	86	40	104
-19	-2	-9	16	+1	34	11	52	21	70	31	88	41	106
-18	0	-8	18	2	36	12	54	22	72	32	90	42	108
-17	+1	-7	19	3	37	13	55	23	73	33	91	43	109
-16	3	-6	21	4	39	14	57	24	75	34	93	44	111
-15	5	-5	23	5	41	15	59	25	77	35	95	45	113
-14	7	-4	25	6	43	16	61	26	79	36	97	46	115
-13	9	-3	27	7	45	17	63	27	81	37	99	47	117
-12	10	-2	28	8	46	18	64	28	82	38	100	48	118
-11	12	-1	30	9	48	19	66	29	84	39	102	49	120

PHYSIOGRAPHY

Topography and Landforms

Physiographically, the area is in the northeasternmost extension of the Basin and Range Province of the Intermontane Plateaus (Fenneman, 1931, pl. 1). It is in the Great Basin Section which is characterized by isolated ranges separated by aggraded desert plains. Three north–south trending mountain masses occur in the basin. They are the Pocatello and Bannock Ranges on the west, the Portneuf Range through the center, and the Chesterfield Range and Soda Spring Hills on the east. The three mountain lineaments delimit two roughly parallel, intermontane valley areas–Marsh Creek valley on the west and Portneuf and Gem Valleys on the east. The two valley areas are connected by a gorge about 18 miles long, cut through the Portneuf Range. The general land–surface altitudes in the upper valley (Portneuf and Gem Valleys) range from about 5,400 to 5,800 feet above mean sea level, whereas the general land–surface altitudes in the lower valley (Marsh Creek valley) range from about 4,500 to 5,000 feet. Extreme altitudes in the basin range from about 4,485 feet on the valley floor in the gap at Portneuf to 9,260 feet atop Bonneville Peak, about 6 miles southeast of Inkom, in the Portneuf Range.

The most prominent landform in the upper valley is an extensive basalt (lava) plain that makes up the surface of the southern half of the valley (see fig. 5 for locations). From its leading edge, which extends roughly from the mouth of the Portneuf Gorge to a point midway between Chesterfield and Hatch, the basalt surface slopes generally upward toward probable eruptive sources in the Blackfoot Lava Field, east of Tenmile Pass, and in the vicinity of Alexander Crater. In the area between the edge of the basalt plain and the dam of the Portneuf Reservoir, the Portneuf Valley floor is chiefly flat and low in relation to the surrounding plain. North of the reservoir, the valley narrows considerably and extends into a topographically rugged upland in the extreme northern part of the basin.

Apparently, basalt from the upper valley flowed through the Portneuf Gorge into the lower valley where it forms a low-lying plateau on the east side of Marsh Creek. This plateau extends from about 2 miles north of Arimo northward to the confluence of Marsh Creek and Portneuf River. Beyond the confluence, the basalt forms terraces along the river downstream to Portneuf Gap. Other notable landforms in the lower valley are deeply dissected pediments on both sides extending the full length of the valley, and alluvial terraces lying between the pediments and the flood plain of Marsh Creek, largely upstream from McCammon.

Drainage

Drainage from the basin joins the Snake River at American Falls Reservoir and thence joins the Columbia River drainage to the sea. The Portneuf River and its largest tributary, Marsh Creek, are the major streams in the study area. The total length of the Portneuf River within the basin boundaries of this study is about 70 miles. The pattern of drainage is shown in figure 9.

Upper Valley

Only that part of the upper valley north of the basalt plain is drained surficially. Intermittent streams flowing out of the mountains along the east and west sides of the basalt plain lose their entire discharge to the ground before they reach the basalt surface. Part of the lost discharge finally joins the Portneuf River as ground–water discharge from springs that occur in and about the river flood plain in the west part of the upper valley where the river flows into the Portneuf Gorge. Similarly, with the possible exception of Topance Creek, streams that flow onto the alluvial flat in the central part of the upper valley, such as Twentyfourmile, Eighteenmile, and King Creeks, lose most, if not all, of their discharge before they reach the river. Some water from Topance Creek is diverted into Portneuf Reservoir and thus into Portneuf River. However, water in the other creeks mentioned is either diverted for irrigation or seeps into the subsurface. The river–channel gradient between Portneuf Reservoir and a point about 6 miles downstream is only about 5 feet per mile. The water table is at or near land surface causing marshy tracts of land in that general area. Thus the central part of the upper valley is poorly drained in places.

The channel gradient steepens appreciably as the river flows through Portneuf Gorge, dropping about 575 feet in the 25–mile reach (23 feet per mile) between the outlet from the upper valley area and McCammon. Under natural conditions, the river gains water as it flows through the gorge. It receives ground water from seeps and springs (including discharge from hot springs) and the discharge from Pebble, Fish, Dempsey, and Bob Smith Creeks, and a number of smaller tributaries.

Lower Valley

Marsh Creek flows generally northward from its headquarters area near Red Rock Pass to its confluence with the Portneuf River near Inkom. It flows sluggishly in a valley whose major features were formed during the massive flood of Lake Bonneville waters to the Snake River (Malde, 1968). Its channel meanders over a flood plain that is much larger than could have been formed by the present–day stream. Because the stream gradient is low, about 4.5 feet per mile, and the water table is at or near land surface, marshy areas occur along much of the flood plain. A large part of the discharge of Marsh Creek comes from springs. Probably the only perennial tributaries are North Fork, Birch, and Hawkins Creeks. Because much of the discharge from these creeks is diverted for irrigation during the growing season, most of the late–summer discharge of Marsh Creek is due to springs and irrigation return flow. Flow in the tributaries that rise in many small canyons in the mountains to the east and west is intermittent and most, if not all, of the flow is lost by seepage into the valley–fill sediments before reaching Marsh Creek. Much of the lost flow, however, reappears as springs and seeps along the Marsh Creek channel and flood plain. The total length of Marsh Creek, exclusive of its north fork, is 52 miles.

Near McCammon, the Portneuf River bends sharply northward and flows in a channel on the east side of the low–lying basalt plateau in the lower valley. At its confluence with Marsh Creek near Inkom, the river again beds sharply and flows westward through Portneuf Gap, then northwestward to American Falls Reservoir.

Climate

Climatic conditions in the basin are variable, largely because of the appreciable topographic relief. Figure 3 shows the areal distribution of precipitation based on the period 1920–67. Annual average precipitation ranges from less than 15 inches on the valley–floor areas near Downey and Bancroft to as much as 35 inches on some of the higher mountains.

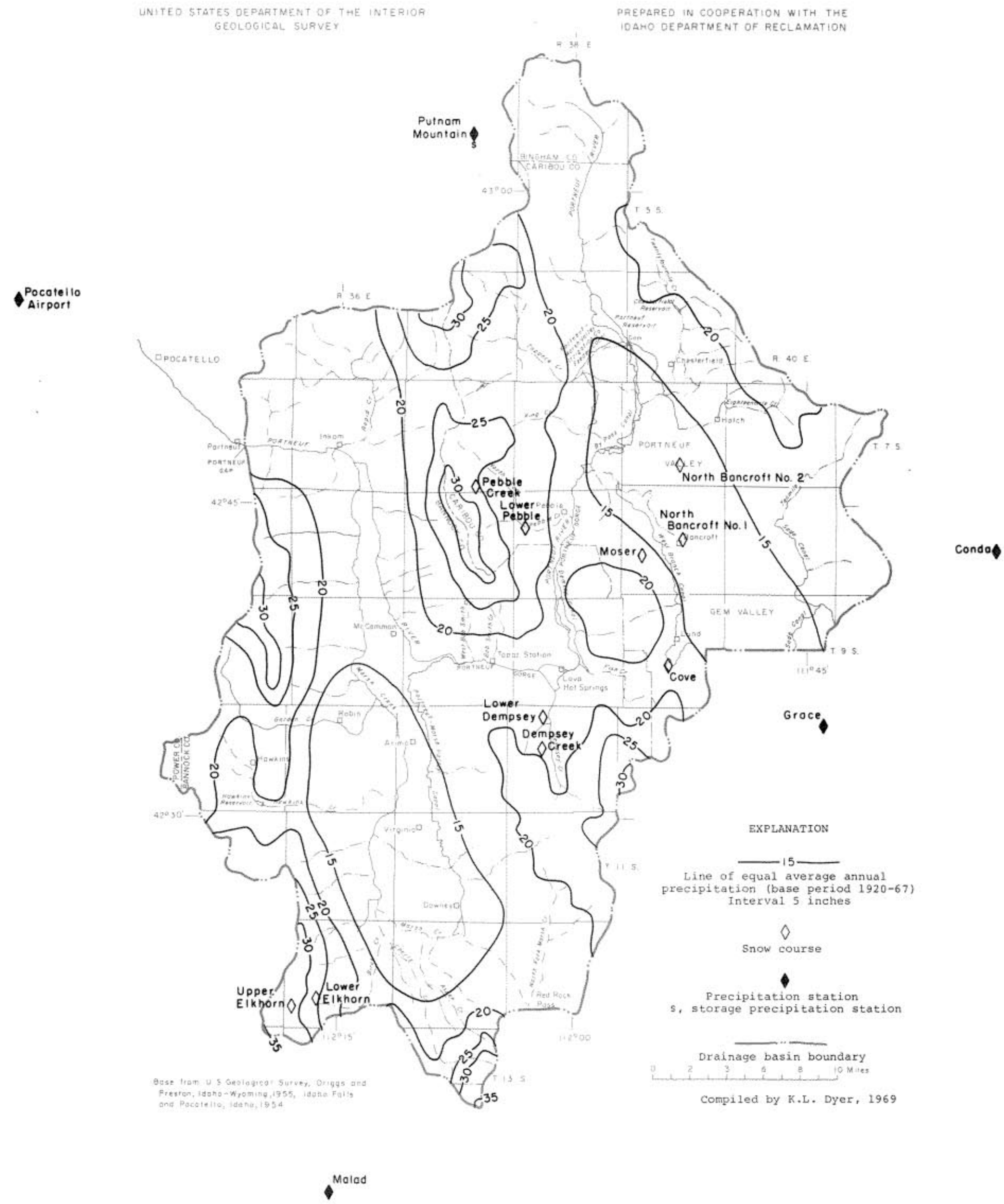

FIGURE 3.-- Distribution of precipitation on the Portneuf River basin, Idaho.

Conditions are generally semiarid over much of the valley lowlands and subhumid in the upper benchlands and in the mountains. Humid conditions may exist in some high–altitude forested areas. Because summer precipitation is generally low and afternoon temperatures are high, arid conditions may exist seasonally in the lower valley areas.

Earlier precipitation maps covering the Portneuf River basin are in gross disagreement with each other. For this reason, additional new data now available from stations in and near the basin were used to construct a new precipitation map. Precipitation data from short–term stations were carefully adjusted by correlation with longer records to obtain estimates for precipitation during the 1920–67 base period. Precipitation in intermountain basins is highly dependent upon altitude and general topography. For this reason, precipitation at a given point in the Portneuf River basin is dependent upon the surrounding altitudes as well as the altitude at that point. Therefore, the concept of effective altitude, rather than actual altitude, was used in plotting the effects of altitude on precipitation. This concept was developed by Peck and Grown (Peck, 1962) for use along the Wasatch Front in Utah, and is defined as the average of the altitude obtained at eight points of the compass a mile and a half from the point.

Weather records are sparse in the basin. Early stations now abandoned were maintained at Downey and Chesterfield. Records at these stations were obtained during relatively dry years and do not represent average conditions in these valleys. Monthly and annual averages of precipitation data obtained from Weather Bureau records for these stations are as follows:

Month	Average precipitation (inches) Chesterfield (1894–1920)[1]	Downey (1895–1902)[2]
January	1.28	0.84
February	1.06	.45
March	1.33	1.24
April	1.03	1.10
May	1.86	1.27
June	1.28	.42
July	.86	.28
August	1.03	.40
September	.83	.36
October	1.07	.98
November	1.00	.68
December	1.14	.78
Annual (period of record)	13.77	8.80
Annual (adjusted to 1920–67 base period)	16.55	12.03

[1]Chesterfield records are partial for years 1894, 1918–22. Averages are computed from available records only.

[2]Downey records are partial for years 1895–97. Averages are computed from available records only.

More recent records of temperature and precipitation were collected for the period 1949–67 at McCammon. These records are compared on figure 4 with the records at Pocatello and Grace, two stations outside of, but near, the periphery of the basin. Average monthly temperatures at McCammon are in close agreement with those at Pocatello but are somewhat warmer than those at Grace. However, the distribution of average monthly precipitation at McCammon is more like that at Grace than at Pocatello. Climatic conditions at Grace are probably similar to those in much of the upper Gem and Portneuf Valleys.

Several snow courses are measured within the basin. Their locations are shown in figure 3. Only the Pebble Creek (1945–61) and Dempsey Creek (1956–69) courses have sufficiently long records to warrant averages at this time. The average of the annual maximum water content of the snow accumulations at those stations for the periods indicated above is 14.6 and 11.4 inches, respectively.

GEOLOGIC UNITS AND THEIR WATER–BEARING CHARACTERISTICS

For the purposes of this study, the geologic formations in the basin are grouped into units of pre–Tertiary, Tertiary, and Quaternary ages. Table 1 gives a generalized description of the geologic units and their water–bearing characteristics. Figure 5 is a compilation of the generalized geology in the basin and is based on previous mapping done by those authors whose works are referenced in the figure. Where the work of different investigators in adjacent areas did not coincide, arbitrary geologic–boundary connections have been made. Because field geologic mapping was not a part of this reconnaissance study, aerial photographs were used to extend contacts into areas not covered by available maps. Because no detailed field mapping has been done in Marsh Valley, that part of figure 5 should be considered as highly generalized. However, the occurrence of the geologic units in Marsh Valley was discussed by Strawn (1964) and Twiss (1939) and their works were used as guides to complete the map.

The geohydrologic sections in figure 6 which illustrate geohydrologic conditions in aquifers underlying major areas of ground–water pumping, were drawn using drillers' logs of wells. The sections indicate the subsurface conditions that may be expected in wells drilled in the general areas traversed by the sections. The thickness of the Quaternary basalt as drawn in section B–B' was partly based on preliminary geophysical work that was done about 5 miles to the south in Gem Valley. The sections are necessarily generalized because of the complete lack of geohydrologic test drilling anywhere in the basin.

Table 1. Description and water-bearing characteristics of geologic units in the Portneuf River basin.

System	Geologic unit	Description	Water-bearing characteristics
Quaternary	Alluvium and colluvium	Soil, clay, silt, sand, gravel, and boulders. Includes well-sorted Holocene alluvium deposited in stream channels and stream floodplains; lake clays interbedded with older alluvium in subsurface; alluvial fans at the base of mountain slopes; hill wash and landslide debris generally composed of poorly sorted rock fragments derived from nearby sources; and older alluvium. In some places underlies basalt and overlies Tertiary sediments from which it is difficult to differentiate. Includes windblown (loess) sediments as overburden.	Sand, gravel, and boulder units are the major source of supply to irrigation and domestic wells in Marsh Creek valley and in northern part of Portneuf Valley. Specific capacities* (from reported data) of wells range from less than 3 to as much as 1,200; at some places part of yield may be from the underlying Tsl (Salt Lake Formation).
	Travertine	Calcium carbonate deposit. Generally light-buff or cream colored; ranges from fine-textured hard varieties, to coarse-textured open or cavernous varieties. Probable source is mineralized springs. Occurs as high, dam-like terrace deposits in Portneuf River gorge, especially near Lava Hot Springs.	Unknown as source of supply. Where saturated and of sufficient thickness, may be a good local source.
	Basalt	Igneous extrusive flow rock (lava) and cinders. Basalt is generally medium-dark gray. Cinders are generally reddish brown. Textural varieties range from massive, very fine grained to vesicular. Fractured, fissured, and jointed; shows collapsed structure in places.	Major source of supply to irrigation wells in southern half of Portneuf and northern part of Gem Valleys. Magnitude of yield depends on local permeability of the formation at individual well sites. Specific capacities of wells range from about 2 to 3,000.
Tertiary	Salt Lake Formation	Conglomerate, sandstone, grit, white calcareous clay, and volcanic tuff. Soils formed on surface are commonly white or light colored and interspersed with gravels of largely local origin. Contains boulders as much as 4 to 5 feet in diameter; matrix of conglomerate is white, relatively soft, loose textured, and calcareous.	Little known as to water-bearing capabilities, largely because it is difficult to distinguish from older alluvium in drillers' logs. Also where unit is penetrated, the well generally is producing also from older alluvium. A good source of supply at some places.
Pre-Tertiary	Bedrock, undifferentiated	Consolidated sedimentary formations; composed of limestone, dolomite, sandstone, quartzite, shale, and chert.	Few wells are known to penetrate bedrock in basin; hence, little data is available. Solution cavities in limestone, if present and when penetrated, will transmit large quantities of water to wells. Secondary openings, such as fractures, in other bedrock formations generally do not yield water at high rates.

* Well yield measured in gpm per foot of water-level drawdown.

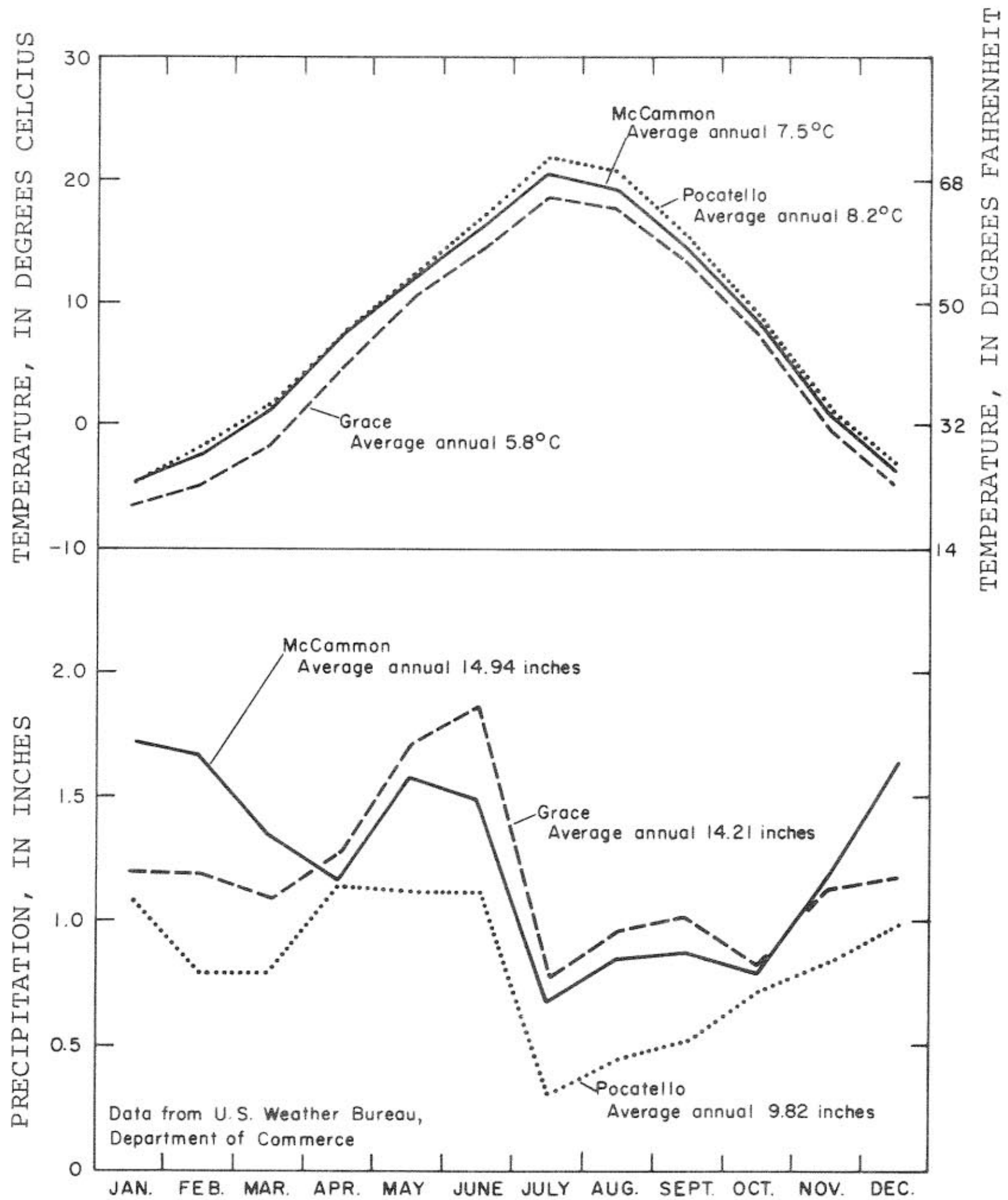

FIGURE 4.-- Average monthly temperature and precipitation at McCammon, Grace, and Pocatello, for the period 1949-67.

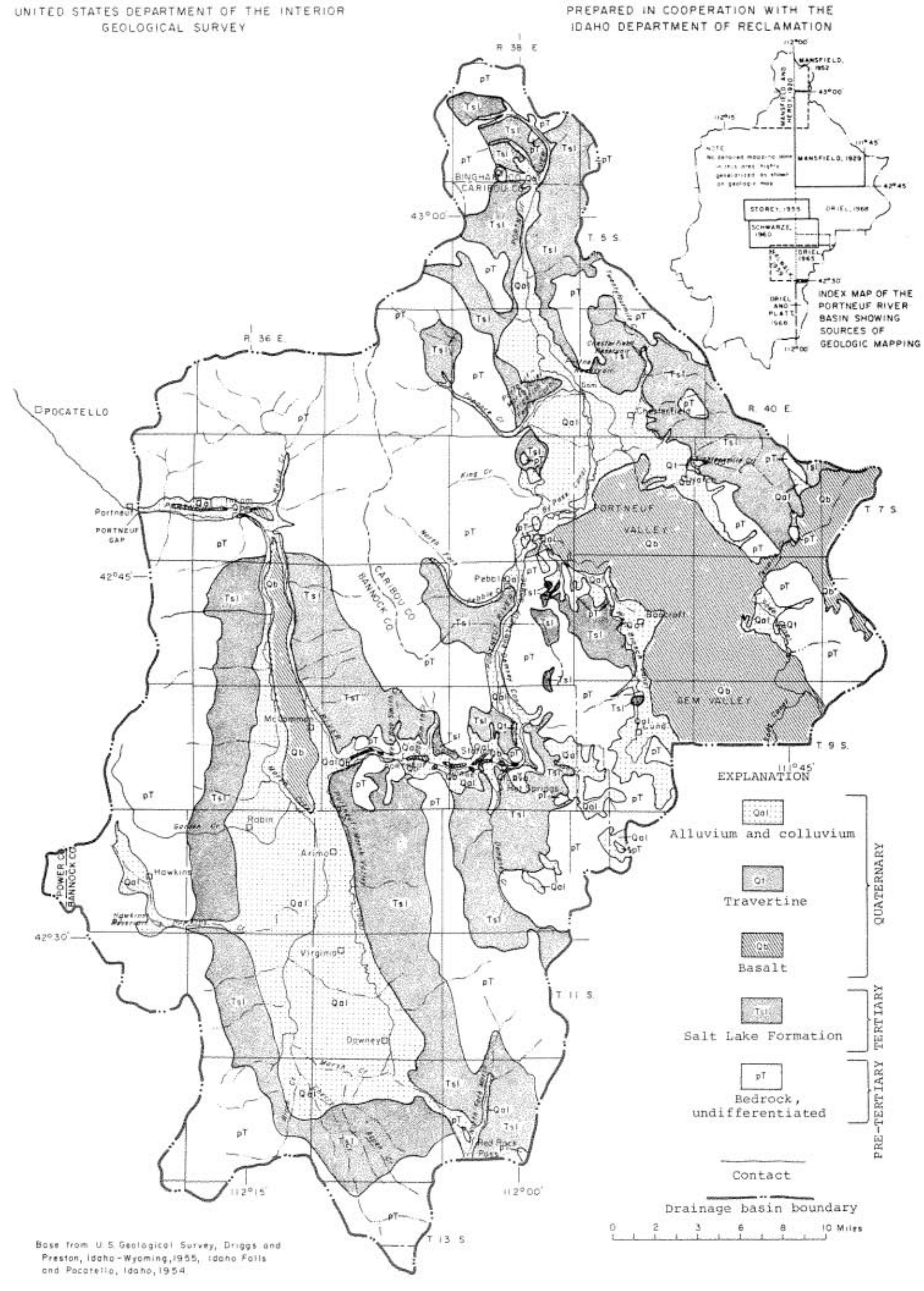

FIGURE 5.-- Map of the generalized geology in the Portneuf River basin, Idaho.

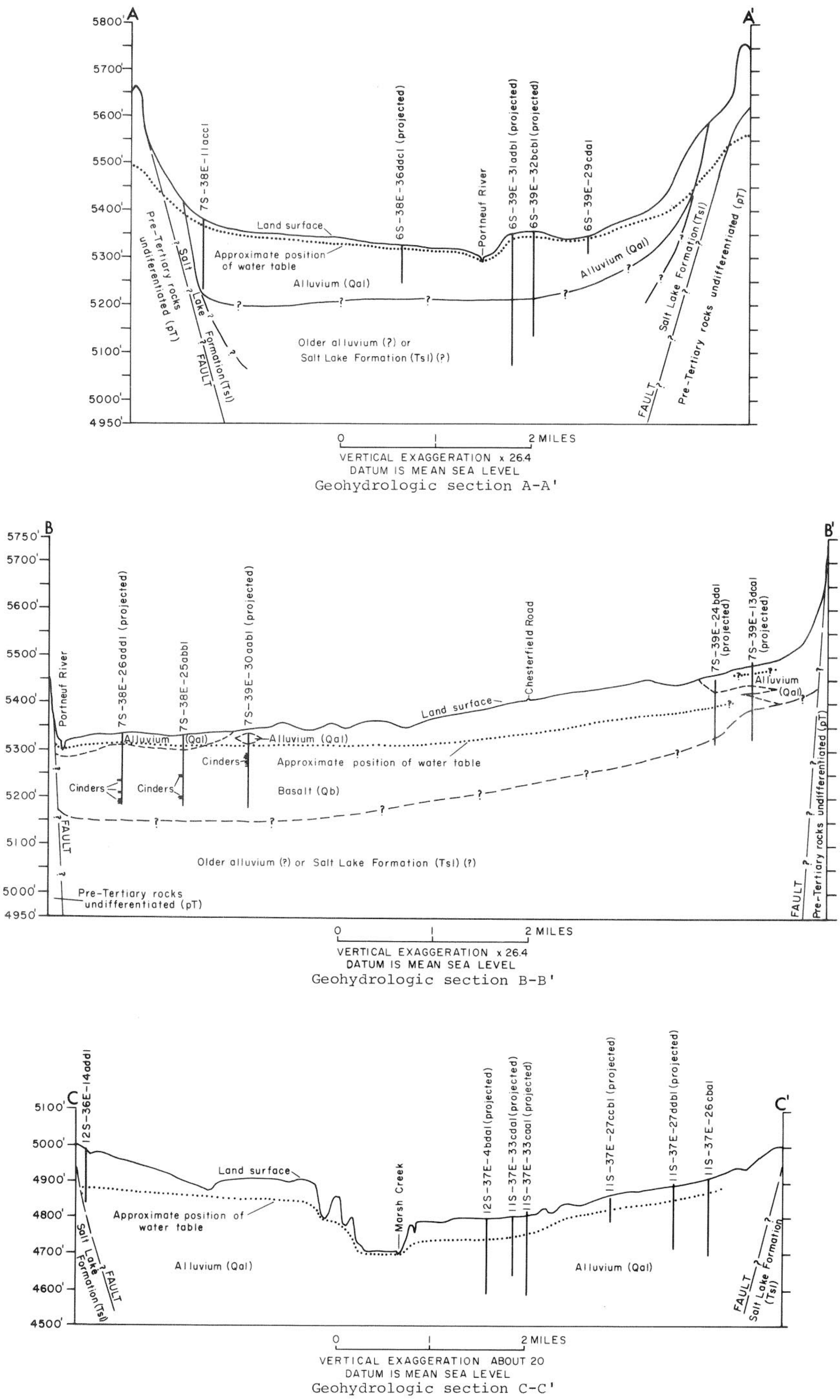

FIGURE 6.-- Geohydrologic sections of Marsh Creek valley and Portneuf Valley, Idaho. (Lines of sections shown on figure 7).

WATER RESOURCES

Sources

It is estimated from the precipitation map (fig. 3) that about 1.2 million acre–feet of precipitation falls on the basin in an average year. By comparison, Mundorff and others (1964, p. 96) estimated 1.09 million acre–feet for that part of the Portneuf River basin above Pocatello, a larger area than is covered in this study. However, they used an average rainfall of 15.6 inches (based on a regional precipitation map); whereas the average precipitation computed for the basin from figure 3 is about 19.6 inches, thus accounting for the difference in estimates. Part of the precipitation flows out of the basin in streams, part is evaporated, part is transpired by native vegetation and crops, and the remainder seeps into the subsurface to recharge the ground–water aquifers. In addition to precipitation, an unknown amount of recharge is postulated to enter the basin as ground–water underflow through Tenmile Pass and through the gap in the mountains near Soda Point. The postulated flow through Tenmile Pass is questionable and is based on the existence of a possible ground–water continuity and southwestward flow from a water table whose altitude is about 5,950 feet in the Blackfoot Lava Field, to a water table whose altitude is about 5,450 feet west of the pass. If the altitude of the water table within the pass or underlying the basin boundary east of the pass rises above 5,950 feet, ground–water flow would not cross the divide.

Subsurface recharge to the basin through the gap near Soda Point is probable because the approximate location of the ground–water divide in Gem Valley as shown in figure 7 is such that it is possible for part of the underflow moving westward through the gap to move northward and another part to move southward. Furthermore, Bright (1963, p. 96), in a study of ancestral drainage patterns of the Bear River system, suggested that the ancestral Bear River most likely flowed northward from Soda Point and, thence, through Portneuf Gorge. If that is so, this ancestral drainage channel may contain permeable deposits that would allow ground–water to move readily northward under favorable hydraulic–gradient conditions.

It is not possible at this time to assign meaningful quantitative values to the amount of underflow that may move into the Portneuf River basin from the Bear River basin. N. P. Dion (oral commun., 1969), in a study of the water resources of the Bear River basin, estimated the average annual ground–water underflow through the gap near Soda Point to be about 56,000 acre–feet. Only some unknown part of that would recharge the ground–water reservoir in the Portneuf River basin. Because the geohydrologic conditions at Tenmile Pass are unknown at this time, no estimate can be made of inflow at that place; if, indeed, inflow actually occurs.

In addition to the natural recharge to the Portneuf River basin, some water for irrigation is imported from the Bear River basin through the Soda and West Branch Canals.

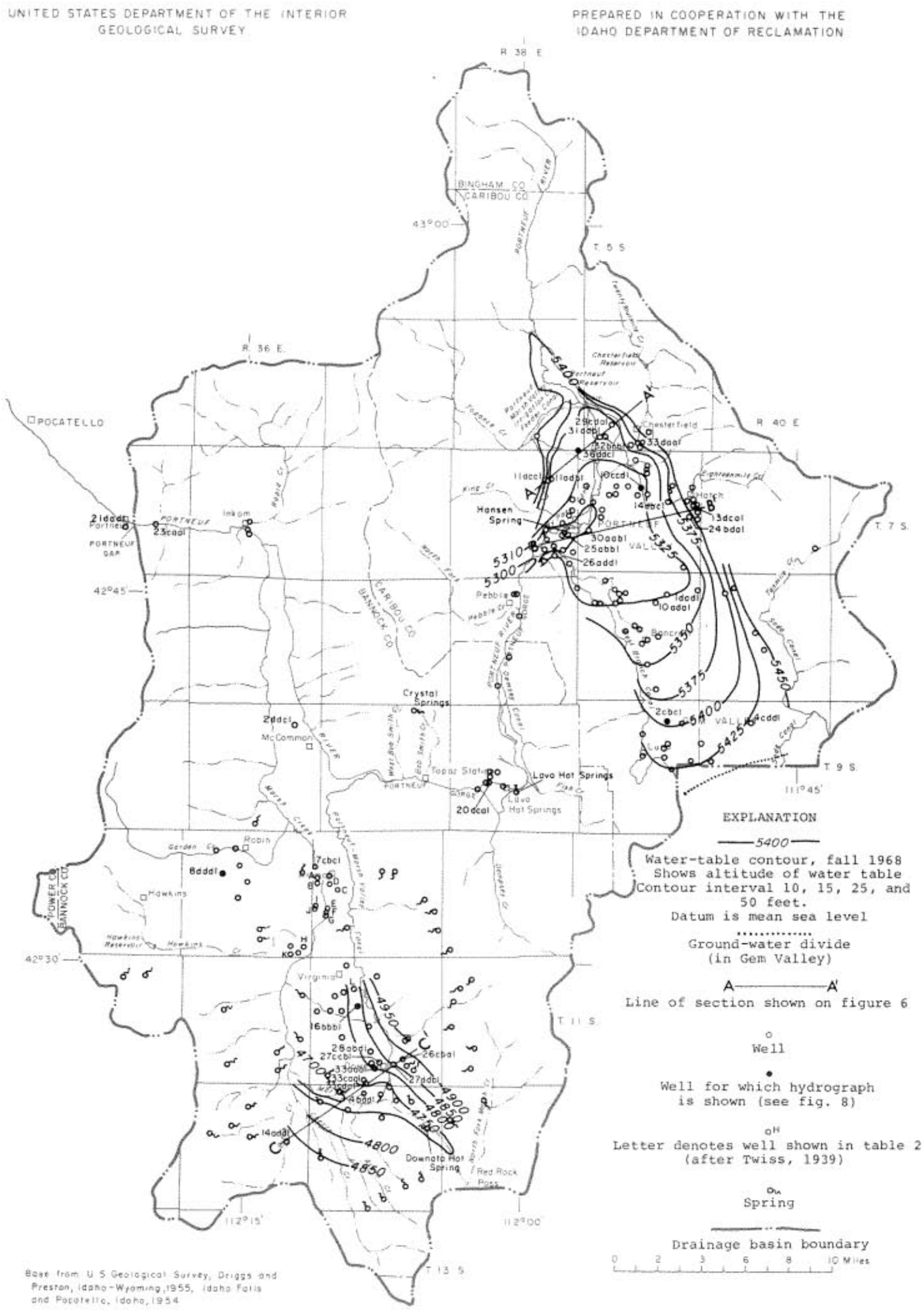

FIGURE 7.-- Contours on the water table in fall 1968 and locations of wells and springs.

Based on rough estimates obtained from canal company personnel, the total importation of water amounts to about 14,000 acre feet per year. On the minus side, about 4,000 acre feet of the discharge of Birch Creek in the Portneuf River basin is diverted annually into Devil Creek in the Bear River basin.

Considering the unknowns and the lack of good quantitative data, a rough estimate of the total input of water to the Portneuf River basin is somewhat in excess of 1.2 million acre feet per year.

Ground Water

Ground water occurs in virtually every geologic unit within the basin. As shown in table 1, the major aquifers (water bearing rocks) are the Salt Lake Formation of Tertiary age and the alluvium and basalt of Quaternary age. The ultimate source of ground water in the aquifers is precipitation that falls upon the land surface. Recharge to the aquifers occurs as (1) precipitation that percolates to the regional water table; (2) leakage from irrigation canals and ditches; (3) seepage from irrigated farm fields; (4) underflow from the adjacent Bear River basin (assumed); and (5) leakage from the southern part of the Portneuf Reservoir (suspected). Ground water discharges from the aquifers by (1) evapotranspiration at places where the water table is near land surface or within reach of phreatophytes (water loving plants); (2) spring flow or seeps at the base of steep slopes or along stream channels and flood plains; (3) pumpage from irrigation, municipal, domestic, and industrial wells, and discharge from flowing wells; and (4) underflow from the basin through Portneuf Gap.

Figure 7 shows contours drawn on the regional water table in autumn 1968. The contours are based on water levels measured in the wells shown on the map and connect points of equal altitude on the water table. Because most wells inventoried during this study were irrigation wells, enough data were obtained to contour the water table only in major areas of ground water irrigation.

Ground water in the basin is constantly moving. Under natural conditions, it moves from areas of recharge down the hydraulic gradient to areas of discharge. The direction of natural ground water movement is perpendicular to the ground water contours; thus, as shown on the map, ground water in the basin moves from the highland areas toward the axes of the valleys, and downvalley in the direction of streamflow. Vertical upward movement through leaky confining strata may occur in some areas where water table aquifers are underlain by artesian aquifers.

Ground water in the basin occurs under both water table and artesian conditions. Most of the wells tap water table aquifers, but artesian aquifers are tapped in places. Well 6S 39E 33daa1, which is listed in table 4 and is near Chesterfield, taps a seemingly local artesian aquifer. Well 7S–39E–14dbc1, at Hatch, reportedly flows at times and a number of other wells near Hatch have shallow water levels that are higher than the regional water table. Those conditions indicate that an artesian aquifer, probably of appreciable extent, occurs in the vicinity of Hatch. Table 2, taken from Twiss (1939), lists data pertaining to flowing wells in the vicinity of Arimo. The approximate locations of those wells are included in figure 7. It was Twiss' opinion that the artesian conditions near Arimo were due to lakebeds at different depths in the valley fill and that the wells were not all completed in the same artesian aquifer. None of the wells listed in table 2 were visited during this study; however, a chemical analysis was made of water from well 10S–37E–7cbc1 (table 3) which is in the same vicinity. Although the chemical makeup of the water from well 10S–37E–7cbc1 is not greatly different, except in its sodium content, from that of water from wells tapping water–table aquifers, the temperature of the artesian water is consistently about 3° to 8° C warmer and suggests relatively deep circulation for the artesian water.

Generally, wells are drilled only deep enough to obtain water for the needs at hand. Thus, deep geologic and hydrologic data are lacking in the basin. Recent geophysical work done in Portneuf and Gem Valleys (Mabey and Oriel, 1969) indicated that the central part of these valleys is structurally a trough (graben) that is deepest in the area north of Bancroft and that may contain as much as 8,000 feet of Tertiary (Salt Lake Formation) strata overlain by younger basalt and alluvial deposits. If these strata are porous and permeable, there is a tremendous volume of ground water in storage in these valleys.

Water–Level Fluctuations

As a part of this study, six wells were selected to monitor for fluctuations in ground–water levels. Three of the wells were equipped with continuous water–level recorders and three were measured periodically. The locations of the observation wells are shown in figure 7; the hydrograph record for each is shown in figure 8. Except for well 9S–39E–2cbc1, the records are not long enough to complete one annual cycle of fluctuation; therefore, little interpretation of the records can be made. Interpretation is confounded further because an unusually large amount of recharge in the spring 1969 made that period nonrepresentative of normal conditions.

Long–term variations in water level in the Portneuf River basin are unknown, but in similar or nearby basins where records are available, hydrographs are used to correlate water–level changes with other known hydrologic events. Under natural conditions, water levels are generally highest in the spring during the period of maximum recharge; decline through the summer when evapotranspiration rates are high and discharge exceeds recharge; tend to level out, but continue downward, in the fall; are lowest in winter when most

Table 2. Characteristics of flowing wells in the vicinity of Arimo, Idaho. (From Twiss, 1939.)

Well	Owner	Location	Elevation (feet)	Depth (feet)	Flow in gallons per min.	Temperature (°C)	Remarks
A.	Charlie Fink	NW¼ sec. 18, T. 10 S., R. 37 E.	4,630	380	1¼	15½	
B.	Charlie Fink	NW¼ sec. 18, T. 10 S., R. 37 E.	4,627	410	2¼	14 3/4	
C.	Mr. Cole	SW¼ sec. 17, T. 10 S., R. 37 E.	4,640	-	1¼	14 3/4	
D.	J. E. Goodman	NE¼ sec. 18, T. 10 S., R. 37 E.	4,660	300±	8	20½	Pressure very good (relatively)
E.	Aaron Evans	SE¼ sec. 19, T. 10 S., R. 37 E.	4,650	425	1½	16½	
F.	Leland Evans	SE¼ sec. 19, T. 10 S., R. 37 E.	4,660	425	2	17	
G.	Aaron Evans	SW¼SE¼ sec. 19, T. 10 S., R. 37 E.	4,690	425(?)	3	17	
H.	L. D. Hickman	SW cor., NE¼ sec. 36, T. 10 S., R. 36 E.	4,637	500±	15	15½	
I.	Mr. Ames	SW¼ sec. 19, T. 10 S., R. 37 E.	4,625	-	4	19	Very gassy
J.	Mr. Ames	SW¼ sec. 19, T. 10 S., R. 37 E.	4,625	-	12	19½	Very gassy
K.	W. A. Morson	SW cor., SW¼ sec. 36, T. 10 S., R. 36 E.	4,680	-	2	17	Very slight head
L.	Carl Olsen	NE¼ sec. 8, T. 11 S., R. 37 E.	4,880	570	Small fraction	-	Aquifer at 382 feet

Table 3. Chemical analyses of water in the Portneuf River basin.
(*Chemical constituents expressed in milligrams per liter.*)

Location or designation	Salinity diagram No.	Sample collection date	Temperature (°C)	Silica (Si)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Phosphate (PO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids: Res. at 180° C	Dissolved solids: Calculated	Hardness: As $CaCO_3$	Hardness: Noncarbonate	Specific conductance	pH	Color	Alkalinity as $CaCO_3$	Boron (B)	Percent sodium	Sodium adsorption ratio	Analyst 1/	Remarks
Ground Water																														
6S-39E-33daa1	1	12- 4-68	10	63	-	-	65	20	20	4.1	282	0	36	-	17	0.2	0.4	359	365	244	14	539	8.1	-	-	-	-	0.6	a	Flowing well
7S-35E-21dad1	2	12- 3-68	7	25	-	-	77	31	43	8.6	370	0	47	-	48	.2	2.7	458	464	320	16	777	8.2	-	-	-	-	1.0	a	
7S-36E-21acd1	-	10-30-51	11	2.5	2/0.44	-	55	13	-	-	-	-	10	-	17	.00	.1	232	-	162	-	-	6.8	-	160	-	-	-	b	
21dcb1	-	3-22-62	-	-	2/.00	0.00	48	24	38	-	-	-	39	0.03	21	.22	1.1	400	-	220	-	-	8.5	-	208	-	-	-	b	
21dcc1) 21dcc2)	3	12- 3-68	10	27	-	-	83	34	44	10	400	0	50	-	49	.2	1.8	489	496	347	19	823	8.0	0	-	-	-	1.0	a	Source - 2 wells, 38 feet apart
7S-39E-30aab1	4	7-22-68	9	29	-	-	120	53	24	8.3	576	0	50	-	27	.3	9.0	597	604	516	44	982	7.7	-	-	0.03	-	.5	a	
8S-39E- 1dad1	5	7-22-68	12	38	-	-	156	72	42	9.8	820	0	42	-	13	.2	4.5	741	757	684	12	1,200	7.7	-	-	.03	-	.3	a	
22abb1	-	7-25-56	9	3.4	.00	.00	86	41	-	-	-	-	44	.07	51	.10	-	532	-	390	-	-	7.4	-	-	-	-	-	b	
22bac1	-	7-25-56	9	3.5	-	.0	102	51	-	-	-	-	64	.20	51	.1	-	610	-	3/472	-	-	7.4	-	356	-	-	-	b	
9S-36E- 2ddc1	6	12- 3-68	9	30	-	-	88	35	33	6.3	397	10	43	-	35	.1	4.9	468	480	364	22	769	8.3	0	458	-	-	.8	a	
9S-38E-20dca1	7	12- 7-68	12	42	-	-	79	39	40	13	439	4	40	-	31	.3	6.8	495	511	358	0	801	8.3	-	-	-	-	.9	a	
9aad1	8	8-16-61	-	-	-	-	88	47	47	3.5	437	0	75	-	59	-	-	564	-	-	-	915	7.9	-	-	.07	-	1.0	b	
16ada1	9	8-16-61	-	-	-	-	83	27	43	1.2	332	6	51	-	54	-	-	444	-	-	-	756	8.1	-	-	.07	-	1.0	b	
9S-40E- 4cdd1	10	7-22-68	12	30	-	-	80	84	47	9.7	672	0	49	-	22	.7	13	658	665	546	0	1,070	8.0	-	-	.09	-	.9	a	
10S-37E- 7cbc1	11	12- 3-68	19	81	-	-	41	17	54	25	302	0	3.6	-	41	.5	6.9	403	419	172	0	617	8.1	5	-	-	-	1.8	a	Flowing well
11S-37E-27ddb1	12	12- 2-68	10	20	-	-	61	26	14	1.2	272	0	13	-	36	.2	4.0	294	309	259	36	552	7.7	0	-	-	-	.4	a	
Surface Water																														
Marsh Creek near McCammon	16	4-24-60	6	35	-	-	68	27	44	6.7	321	0	45	-	51	0.3	2.0	444	437	282	20	716	8.1	10	-	-	25	1.1	a	
Portneuf River near Chesterfield	17	7-22-68	19	10	-	-	37	18	9.4	3.0	180	0	22	-	11	.3	.7	207	200	166	18	342	7.9	-	-	0.04	11	.3	a	
Do	18	4-23-60	6	17	-	-	70	27	14	4.9	300	8	38	-	16	.3	.4	349	344	286	26	571	8.4	5	-	-	9	.4	a	
Portneuf River near Pebble	19	7-22-60	20	7.0	-	-	51	34	17	4.7	312	0	32	-	17	.3	.4	320	316	268	12	547	7.8	-	-	.04	12	.5	a	
Portneuf River near Portneuf	20	8-29-59	18	34	0.02	-	70	31	50	10	359	5	47	-	48	.4	1.2	473	474	302	0	473	8.3	5	-	-	26	1.3	a	
Do	21	4-24-60	8	24	-	-	68	22	28	6.2	302	0	34	-	31	.2	2.3	360	365	260	13	605	8.2	10	-	-	19	.8	a	
Portneuf River near Pocatello	22	4-14-60	8	22	-	-	64	25	27	5.8	292	0	34	-	30	.2	3.1	358	355	260	21	604	7.8	10	-	-	18	.7	a	
Do	23	8- 3-60	22	25	-	-	55	31	39	7.8	303	0	39	-	42	.4	2.7	396	391	262	14	642	8.2	10	-	-	24	1.1	a	
Rapid Creek near Inkom	24	4-23-60	3	11	-	-	16	4.2	5.2	.8	67	0	6.6	-	5.0	.1	1.0	90	83	57	2	138	7.3	15	-	-	17	.4	a	
Springs																														
Arimo municipal:																														
Arimo Springs	-	6-27-52	-	-	0.00	-	67	38	-	-	-	-	46	-	55	0.30	-	4/565	-	324	-	-	7.5	-	318	-	-	-	b	
Arkansas Springs	-	6-27-52	-	-	.00	-	51	20	-	-	-	-	5	-	21	.00	-	4/274	-	210	-	-	7.4	-	200	-	-	-	b	
Bancroft municipal:																														
City springs	-	7-25-56	-	3.3	.00	0.00	73	33	-	-	-	-	17	0.40	32	.10	-	4/404	-	322	-	-	7.5	-	322	-	-	-	b	
Railroad spring	-	7-25-56	-	2.3	.00	.00	62	30	-	-	-	-	10	.30	25	.10	-	4/330	-	284	-	-	7.2	-	288	-	-	-	b	
Downata Hot Spring	15	7- 1-57	48	32	.04	.00	44	13	24	9.0	218	0	20	.05	19	.3	0.0	266	-	163	0	432	7.7	0	-	-	23	0.8	a	Radiochemical analysis available
Downey municipal springs	-	3- 9-65	-	-	2/7.05	.01	60	28	-	-	-	-	7	-	4	.30	1.5	4/240	-	260	-	-	7.5	-	232	-	-	-	b	
Hansen spring	13	12- 4-68	10	32	-	-	84	52	25	9.0	470	0	56	-	27	.2	6.3	501	522	424	38	864	7.4	0	-	-	-	.5	a	
Lava Hot Springs No. 1	14	3-20-52	40	29	.07	-	100	34	127	30	493	0	78	-	147	.4	1.2	776	-	390	0	1,280	-	5	-	0.34	39	2.8	a	
Lava Hot Springs municipal springs	-	1-18-45	9	-	.0	0	42	19	-	-	-	-	6	-	13	.00	-	4/212	-	182	-	-	7.6	-	176	-	-	-	b	
McCammon municipal:																														
Crystal Springs	-	9- 5-50	12	-	2/.04	-	44	13	-	-	-	-	4	-	44	.00	.4	4/176	-	166	-	-	7.5	-	162	-	-	-	b	

1/ a - U.S.G.S.; b - State of Idaho

2/ Total iron

3/ Ca, Mg

4/ Total solids

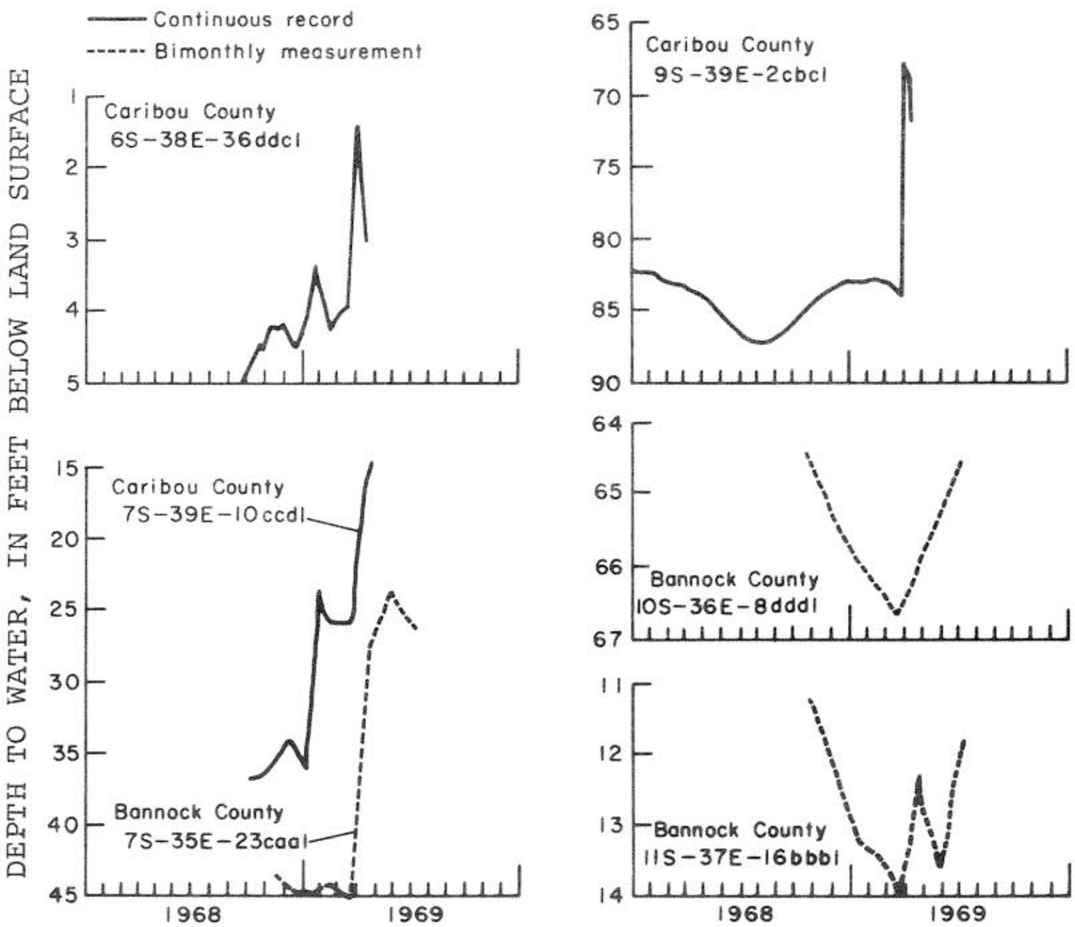

FIGURE 8.-- Hydrographs of observation wells.

evapotranspiration has stopped; and rise again in the spring to complete the annual cycle. In irrigated areas, this cycle may be altered considerably. Where ground–water irrigation is prevalent, the annual lowest water levels usually occur in late summer owing to regional pumpage, as indicated in well 9S–39E–2cbc1. In surface–water irrigated areas, where canal losses and seepage from fields may constitute the principal recharge, high water levels usually occur in late summer. In areas of mixed irrigation, any combination of the above events may occur.

The common use of observation–well hydrographs is to determine long–term water–level trends. If water levels annually return to about the same position, climatic cycles being considered, then recharge to and discharge from the ground–water aquifer are in near balance. However, if water levels follow a continuing long–term declining trend, then discharge exceeds recharge and ground water is being mined from the aquifer.

There is no evidence to date that any of the aquifers in the Portneuf basin are being overdeveloped by pumping for irrigation; in fact, comparison of the water–table map in figure 7 with the water–table map of Stearns and others (1938, pl. 19) indicates little, if any, change since the 1928–29 period. However, because long–term continuous water–level data are lacking in the basin, some of the observation wells selected for use in this study should be measured on into the future. These measurements would provide a record of such water–level changes as may occur as a result of use of the basin's water resources.

Water levels in 53 wells were measured in late March 1969. These levels were compared with water levels measured in the same wells in the fall of 1968. Water–level changes ranged from a 6–foot decline to an 18–foot rise. The maximum rise was in well 7S–38E–11adb1, situated close to the mountain foothills, indicating that spring recharge probably had already started at that place. The maximum decline was in well 11S–37E–28abd1, situated quite far from recharge areas, indicating that there the early spring recharge was not yet fully effective. Changes in 72 percent of the wells were within the range of only 3 feet in either direction.

Well and Aquifer Characteristics

Transmissivity is an aquifer characteristic that is defined as the number of gallons of water, at the prevailing temperature, that will pass in 1 day through a 1–foot wide vertical strip of an aquifer, extending the saturated thickness of the aquifer, under a hydraulic gradient of 1 foot per foot. It may be determined by interpretation of data from properly conducted pumping tests.

In September 1968, a pumping test was made in well 8S–39E–10ada1 by the Idaho Department of Reclamation. The well was pumped continually for about 25 hours at a rate of about 1,575 gpm (gallons per minute). During the test, the maximum drawdown of water level in the pumping well was only 0.6 foot. There was no measurable drawdown of water levels in three observation wells at distances of from 0.7 to 2.7 miles from the pumping well. The test data show that the basalt aquifer at the well has an apparent transmissivity of about 3 million gallons per day per foot.

Meager data are available on the hydraulics of the wells in the basin. Some drillers' reports contain pumping–rate and water–level drawdown data obtained during performance tests made upon completion of the wells. These tests are run for various lengths of time and seldom, if ever, is any notice given to rates of drawdown. However, these data do offer some suggestion of well capabilities. The drawdown and yield data from 44 of the wells listed in table 4 were used to compute specific–capacity values. Specific capacity is a well function and expresses yield in relation to unit drawdown. The values obtained ranged from 2 to 3,000 gpm per foot of drawdown, and the median value was 26 gpm per foot of drawdown. Both the high and the low values were for wells that penetrated basalt, thus illustrating the high variability of yields from wells in the basalt aquifer. This high variability in well yields is indicative of the fact that the ability of the basalt to transmit water is also highly variable.

Springs

There are hundreds of springs and seeps in the basin. They generally occur near the base of small canyons cut into the high mountain slopes and near the base of terraces, at and slightly above stream levels. Both hot (above mean annual air temperature) and cold (mean annual air temperature or below) springs occur; the cold, of course, are much more numerous. The springs supply domestic and irrigation water to many farms, and municipal water to many towns in the basin. They also account for much of the base flow in Marsh Creek and in Portneuf River.

The approximate locations of some of the springs in the basin are shown in figure 7. Many were not visited during this reconnaissance and all the locations of those shown in Marsh Creek valley were obtained from Twiss (1939).

Yields from the different springs vary greatly. Many springs in the mountainous areas are intermittent, flowing only during the wettest parts of the year and deriving their discharge from local sources, whereas many in the lower valley areas are perennial, deriving their discharge from more extensive and distant sources. Crystal Springs (fig. 7) are high in the mountains but are perennial. They provide the entire municipal supply for McCammon and, reportedly, their discharge is greatest in June and least in February or March. Numerous springs occur in the upper valley along the flood plain of Portneuf River from where the river enters Portneuf Gorge to roughly 4 miles upstream. The accumulated yield

Table 4. Records of wells.

Altitude: Feet above mean sea level; to nearest tenth where spirit leveled; whole number and approximate where taken from topographic map or altimeter reading.

Depth to well: To nearest foot below land surface; largely from reported data, some depth soundings.

Casing depth: Feet below land surface to first perforations.

Well finish: 0 - open end; P - perforated casing; X - open hole.

Aquifer: Queired (?) where doubtful
- Qal, Quaternary and/or older alluvium, includes lake deposits
- Qt, Quaternary travertine
- Qb, Quaternary or older basalt
- Tsl, Tertiary Salt Lake Formation
- pT, Pre-Tertiary sedimentary rocks, undifferentiated

Water level: Feet below land-surface datum.

Use of water: I - irrigation; H - domestic; N - industrial; P - public supply; S - stock; U - unused

Remarks: Log - driller's log available; CA - chemical analysis of water available; yield - reported well yield in gpm (gallons per minute), usually obtained during initial well performance test shortly after drilling. Drawdown in feet below static water level in well.

Well No.	Land-surface altitude (feet)	Depth of well (feet)	Casing Diameter (inches)	Casing Depth (feet)	Well finish	Aquifer	Water level Depth (feet)	Water level Date measured	Pump H.P.	Use of water	Date of well completion	Remarks
6S-38E-34adb1	5,450	290	15	-		Qal	12.72	9-25-68	-	U	1965	
36ddc1	5,337.5	64	15	18	P	Qal	5.03	9-20-68	-	U	1959	Original depth - 80 ft; log
6S-39E-29cda1	5,350	40	12	0	P	Qal	3.64	10-30-68	40	I	1964	Log
31adb1	5,350	280	16	10	P	Qal,Tsl?	7.92	9-16-68	-	I	1959	Log
32bcb1	5,350	178	17	28	X	Qal,Tsl?	13.83	9-16-68	-	U	1959	Original depth - 222 ft; log; yield - 750 gpm with 185-ft drawdown
33cac1	5,360	34	16	0	P	Qal	1.88	9-26-68	30	I	1966	Log
33daa1	5,390	220	12	20	P	-	-	-	-	U	1963	Log; flowing; CA
33dbd1	5,375	65	16	0	P	Qal	-	-	25	I	1966	Log
33ddb1	5,375	65	16	0	P	Qal	.51	9-27-68	30	I	1963	
34bbb1	5,425	132	12	21	P	Qal,Tsl?	13.41	9-19-68	-	U	1968	Log; yield - 40 gpm
7S-35E-23caa1	4,504	86	6	-	P	Qal?	43.63	11-16-68	-	U	1960	
7S-36E-21acd1	4,550	59	8	-	-	-	-	-	15	P	-	City of Inkom; CA
21dcb1	4,540	95	12	-	P	-	-	-	75	P	1955	City of Inkom; yield - 1,000 gpm with 14-ft drawdown; CA
21dcc1	4,540	60	12	42	P	Qal	31.80	12- 3-68	7.5	N	1937	Log; CA; original depth - 485 ft; pumps continually
21dcc2	4,540	42	8	20	P	Qal	-	-	7.5	N	1953	Log; yield - 155 gpm with 3.8-ft drawdown
7S-38E-11acc1	5,379.8	200	12	90	P	Qal,Tsl?	10.62	9-23-68		U	1967	Log
11adb1	5,370	250	18	18	P	-	37.66	12- 4-68	100	I	1957	
13adb1	5,340	163	20	60	P	-	14.87	10-30-68	125	I	1962	
13ddb1	5,335	175	-	45	X	Qb	20.18	10-16-68	125	I	-	Log; yield - 1,200 gpm with 68-ft drawdown
23cda1	5,307.0	45	16	39	X	Qal?	1.57	10-29-68	50	I	1966	
24aba1	5,330	135	12	-	O	-	-	-	75	I	1960	Yield - 1,800 gpm
24bdd1	5,320	132	16	21	P	Qb	4.79	10-16-68	100	I	1966	Log; yield - 1,400 gpm with 50-ft drawdown
25abb1	5,330.6	150	-	-	-	Qb	21.32	9-24-68	25	I	1951	Log; yield - 1,800 gpm

Table 4. Records of wells. (Continued)

Well No.	Land-surface altitude (feet)	Depth of well (feet)	Casing Diameter (inches)	Casing Depth (feet)	Well finish	Aquifer	Water level Depth (feet)	Water level Date measured	Pump H.P.	Use of water	Date of well completion	Remarks
7S-38E-25baa1	5,315	151	14	4	X	Qb	6.61	10-29-68	60	O	1950	Log; yield - 1,580 gpm with 16-ft drawdown
25cac1	5,320.7	191	20	24	X	Qb	13.51	10-22-68	60	I	1965	Log
25dac1	5,340	175	-	-	-	Qb	25.82	10-30-68	40	I	-	Log
26add1	5,335	152	16	-	-	Qb	19.99	10-30-68	125	I	1951	Log; yield - 3,000 gpm with 1-ft drawdown
26caa1	5,328.7	150	16	29	X	-	24.78	10-29-68	75	I	1951	Yield - 2,400 gpm with 12-ft drawdown
26ddd1	5,340	100+	18	-	-	-	15.83	10-30-68	60	I	-	
27adc1	5,335	175	-	0	X	-	16.10	10-29-68	-	U	-	
35bad1	5,335	272	18	7	X	Qb	14.67	12- 4-68	150	I	1952	Log; yield - 2,330 gpm with 45-ft drawdown
36abc1	5,340	188	18	40	X	Qb	20.34	10-30-68	100	I	1951	Log; yield - 1,580 gpm with 46-ft drawdown
7S-39E- 3dcc1	5,355	44	22	-	-	Qb	24.25	9-25-68	-	U	-	Original depth - 86 ft
7dcd1	5,322.3	143	16	16	P	-	7.38	9-16-68	75	I	1963	
9ccd1	5,330	165	18	-	X	Qb	-	-	150	I	1954(?)	
9dcc1	5,336.6	125	16	50	X	Qb	24.55	9-25-68	100	I	-	Yield - 2,000 gpm with 2-ft drawdown
10abb1	5,350	90	-	50	X	Qb	23.54	9-26-68	40	I	1959	
10acb1	5,347.4	32	19	-	-	Qb	20.95	9-19-68	-	U	-	Original depth - 86 ft
10ccd1	5,353.7	68	15	6	X	Qb	36.90	10- 3-68	-	U	1961	Original depth - 77 ft; yield - 60 gpm with 30-ft drawdown
12dcc1	5,530.8	367	12	33	P	Qal,Tsl	5.53	10-17-68	125	I	1963	Log; yield - 1,200 gpm with 90-ft drawdown
13caa1	5,496.0	214	10	50	P	Qal	3.18	10- 3-68	30	I	1962	Log; well used to flow; ceased in 1967; yield - 200 gpm
13caa2	5,497.4	60	10	-	-	Qal	-	-	20	I	1935(?)	
13dba1	5,506.1	97	16	26	P	Qal,Qb	19.04	10-18-68	30	I	1954	Log; yield - 500 gpm with 50-ft drawdown
13dca1	5,490	37	18	-	-	Qal?	12.44	10-18-68	5	I	-	
13dca2	5,490	167	18	21	P	Qb	-	-	7.5	I	1954	Log
13ddb1	5,490	-	10	-	-	-	13.95	10-18-68	5	I	-	
13ddc1	5,488.7	-	-	-	-	-	10.56	10-18-68	5	I	-	
14dbc1	5,435	40	12	0	P	-	4.08	9-25-68	-	I	-	Flows sometimes
15acb1	5,371.4	640	15	640	O	-	46.87	9-26-68	-	U	1961	
15bcb1	5,370	111	16	6	X	Qb	40.97	9- 1-67	-	U	1961	Log
16bbc1	5,329.0	65	18	14	X	Qb	17.50	10-24-68	125	I	1967	Log
17ada1	5,330	55	16	12	X	Qb	18.83	9-20-68	125	I	1955	Yield - 3,000 gpm

Table 4. Records of wells. (Continued)

Well No.	Land-Surface altitude (feet)	Depth of well (feet)	Casing Diameter (inches)	Casing Depth (feet)	Well finish	Aquifer	Water level Depth (feet)	Water level Date measured	Pump H.P.	Use of water	Date of well completion	Remarks
7S-39E-17cbc1	5,325	110	14	-	-	-	13.91	9-23-68	75	I	1956	
18dbc1	5,330	150	20	27	X	Qb	6.68	9-23-68	100	I	1964	Log; yield - 1,800 gpm with 65-ft drawdown
20baa1	5,335	66	18	6	X	-	22.67	9-24-68	50	I	1956	
20bdd1	5,335	90	18	10	S	-	18.04	9-24-68	40	I	1958	
24aaa1	5,473.4	540	-	-	P	-	8.22	10-16-68	50	I	-	Yield - 400 gpm with 240-ft drawdown
24add1	5,476.2	118	18	-	-	-	69.94	10-16-68	-	U	-	
24bda1	5,452.4	135	16	33	X	Qb,Qal? Ts1?	57.03	10- 3-68	-	U	1961	Log; yield - 100 gpm
30aab1	5,335.6	160	16	40	P	Qb	25.13	10-17-68	60	I	1956	Log; yield - 1,160 gpm with negligible draw-down; CA
36cbd1	5,500	274	16	23	X	Qb	184.45	10- 4-68	-	U	-	
7S-40E-25cca1	6,260	-	-	-	-	-	72.22	8-10-67	-	-	-	
8S-38E- 3cca1	-	48	6	-	-	-	-	-	2	H	-	
3ccb1	-	149	12	30	P	Qal,Ts1?	29.31	11-14-68	100	I	1961	Log; yield - 1,800 gpm with 60-ft drawdown
10cca1	-	-	6	-	-	-	13.28	10-23-68	-	U	-	
21ddb1	-	175	16	-	P	-	102.39	12- 7-68	110	I	1963	
33bba1	-	64	12	13	P	Qb	1.48	11-13-68	-	I	1960	
8S-39E- 1dad1	5,522.7	207	-	-	-	Qb	192.64	10- 4-68	150	I	1951	Log; yield - 1,600 gpm with 3-ft drawdown; CA
2dcc1	5,517	225	4	-	-	-	197.69	9-11-68	-	H	-	Old farm well
4ccb1	5,402	87	5	-	-	-	71.85	9-10-68	-	U	-	Reported to contain "soda water"
4cdc1	5,397	235	18	7	X	Qb,Ts1?	75.43	9-11-68	-	S	1955	Log; yield - 200 gpm with excessive drawdown
4dcc1	5,415	113	6	-	-	-	(dry)	9-11-68	-	U	-	
5acb1	5,376	260	16	54	P	Qb,Qal?, Ts1?	48.20	9-10-68	70	I	1963	Log; yield - 495 with 183-ft drawdown
6dcb1	5,380	202	-	0	X	Qb	69.14	10-29-68	75	I	1954	Log; yield - 800 gpm
8bcb1	5,385	115	16	-	-	Qb	70.63	12- 6-68	-	H	1966	Log
8bdd1	5,385	293	18	14	X	Qb,Qal?, Ts1?	-	-	50	I	1954	Log; yield - 1,000 gpm with 50-ft drawdown
9bac1	5,434	600	16	-	-	-	110.29	9-10-68	-	U	1968	New well; not yet used
9bcb1	5,425	249	6	-	-	-	97.17	9-10-68	-	U	-	
10ada1	5,524.8	345	12	200	P	Qb	197.50	9-10-68	100	I	1967	Log; yield - 1,575 gpm with 0.6-ft drawdown
14ccc1	5,430.9	108	6	-	-	-	99.94	12- 6-68	-	U	-	Old well
15cba1	5,450	173	-	-	-	Qb	110.10	10-22-68	75	I	-	Log; yield - 1,350 gpm with 5-ft drawdown

Table 4. Records of wells. (Continued)

Well No.	Land-Surface altitude (feet)	Depth of well (feet)	Casing Diameter (inches)	Casing Depth (feet)	Well finish	Aquifer	Water level Depth (feet)	Water level Date measured	Pump H.P.	Use of water	Date of well completion	Remarks
8S-39E-16add1	5,440	290	12	95	P	Qb,Tsl?	96.26	10-24-68	100	I	1967	Log
16cad1	5,435	575	14	100	P	Qb,Qal?, Tsl?, pT	89.86	12- 6-68	-	U	1968	New well; not yet used
21aaa1	5,430	275	18	11	O	Qb	-	-	-	-	1954	Well was never used; plugged at 38 ft
22abb1	5,420	111+	-	-	-	-	82.89	11-13-68	25	P	1909(?)	Emergency use for city of Bancroft; CA
22bac1	5,425	185	-	-	-	Qb	84.68	8-30-67	30	P	1935	City of Bancroft supply; yield - 300 gpm with 0.2-ft drawdown; CA
27acb1	5,460	355	18	14	X	Qb,Qal?, Tsl?	107.97	12 -6-68	-	U	1954	Log; yield - 300 gpm with 45-ft drawdown
34add1	5,440	170	16	20	X	Qb	83.39	11-12-68	130	I	1967	Log; yield - 1,850 gpm with 1-ft drawdown
8S-40E- 5ccc1	5,596.2	240	20	-	-	Qb	195.78	10- 4-68	-	U	-	
5dbd1	5,638.5	265	6	173	X	Qb	-	-	-	S	1969	New well; not yet used
16dcb1	5,545	247	18	150	P	Qb,Qal?, Tsl?	63.80	8-30-67	-	U	1957	Log; yield - 610 gpm with 150-ft drawdown
21daa1	5,508	175	16	97	O	Qb,Qal? or Tsl?	71.66	10-19-68	250	I	1967	Log; yield - 2,288 gpm with 73-ft drawdown
9S-36E- 2ddc1	4,725	75	6	1	P	Qb,Qal?	28.39	12- 3-68	-	N	1961	Log; yield - 20 gpm with negligible drawdown; CA
9S-38E-20aac1	-	103	6	-	-	-	59.13	10-21-68	-	U	-	Old well
20adc1	-	45	8	45	O	Qb,Qal?	-	-	-	N	1963	Log; yield - 20 gpm with 2-ft drawdown
20ccd1	-	56	12	-	-	-	31.44	10-21-68	30	I	-	
20cba1	-	50	-	50	O	Qal	14.45	12- 7-68	-	H	1962	Log; yield - 20 gpm with 5-ft drawdown; cafe well; CA
20dbb1	-	39	10	-	-	-	9.17	12- 7-68	-	H	-	Motel well
21bbb1	-	250	16	180	P	Qb,Qal?, pT	88.99	12- 7-68	100	I	1963	Log
21cdb1	-	-	8	-	-	-	69.20	12- 7-68	-	U	1968	New well; not yet used
9S-39E- 2cbc1	5,480.3	96	6	-	-	Qb?	85.71	10- 7-68	-	U	-	
2ddb1	5,495	132	12	11	O	Qb	-	-	30	I	1953	Log; yield - 1,350 gpm with negligible drawdown
9aad1	5,483.5	84	6	-	-	-	60.09	10- 7-68	½	H	-	Old well; CA
10ddd1	5,475.4	91	6	-	-	Qb?	57.04	12- 6-68	-	H	-	
11cbc1	5,480	-	6	-	-	Qb?	63.46	8-28-67	-	U	-	
13dbb1	5,485	175	16	60	X	Qb	62.11	10-31-68	200	I	1967	Log
14cdc1	5,485	-	6	-	-	Qb?	63.06	11-12-68	½	H	-	
15ada1	5,495.4	150	6	12	X	Qb?	110.80	10-29-67	½	H	-	

Table 4. Records of wells. (Continued)

Well No.	Land-surface altitude (feet)	Depth of well (feet)	Casing Diameter (inches)	Casing Depth (feet)	Well finish	Aquifer	Water level Depth (feet)	Water level Date measured	Pump H.P.	Use of water	Date of well completion	Remarks
9S-39E-16ada1	5,486.4	51	6	-	-	-	29.22	12- 6-68	3/4	H	-	Old well; CA
9S-40E- 4cdd1	5,576.0	200	4	137	P	Qb	146.45	12- 6-68	-	H	1964	CA
7ccc1	5,507.9	150	4	-	-	Qb?	82.00	8-25-67	-	U	-	Old well
18dcb1	5,525	190	18	24	P	Qb	92.00	10-31-68	100	I	1954	Log; yield - 1,340 gpm with 9-ft drawdown
10S-36E- 4cdb1	-	-	-	-	-	-	10.09	10-29-68	40	I	-	
5dcc1	-	120	16	69	P	Qal	31.01	10-29-68	40	I	1963	Log; yield - 700 gpm
8ddd1	-	216	16	115	P	Qal,Tsl?	64.35	10-29-68	-	I	1966	Log; yield - 450 gpm with 200-ft drawdown
9dab1	-	-	-	-	-	-	-	-	75	I	-	
15bcb1	-	230	12	90	P	Qal?,Tsl?	-	-	125	I	1961	Log; yield - 1,350 gpm with 6-ft drawdown
21aba1	-	285	20	150	P	Qal?,Tsl?	138.70	10-29-68	200	I	1965	Log; yield - 2,600 gpm with 178-ft drawdown
36bcc1	-	32	4	-	-	Qal	(dry)	10-28-68	-	U	-	
36caa1	-	232	4	215	0	Qal?,Tsl?	-	-	-	S	1962	Log; flows
10S-37E- 7cbc1	-	400(?)	3	-	0	-	(flow)	12- 3-68	-	S	-	Old well, water temp. 19°C; CA
18aab1	4,735	585	-	-	-	Qal?,Tsl?	14.33	11-14-68	25	P	1958	Log; flowed when drilled; village of Arimo supply
4dad1	5,000	312	16	35	P	Qal?,Tsl?	2.35	10-28-68	25	I	1961	Log; yield - 450 gpm with 155-ft drawdown
5abb1	-	445	16	40	P	-	15.15	10-28-68	30	I	1962(?)	
8bdd1	4,822	109	16	49	P	Qal	45.18	10-25-68	30	I	1954	
8cbb1	4,799	42	16	23	P	-	22.47	10-24-68	125	I	1964	
16bbb1	4,842	65	16	-	-	-	11.24	10-24-68	-	U	-	
17bdb1	4,828	42	42	-	-	Qal?	33.15	10-24-68	50	I	-	Dug well
18adb1	4,811	-	-	-	-	-	28.21	10-22-68	50	I	1963	
18bcd1	4,791	80	16	31	P	Qal	-	-	25	I	1954	Log; yield - 1,680 gpm with 8-ft drawdown
20cab1	4,822	316	16	42	P	Qal,Tsl?	30.55	9-27-68	100	I	1966	Log; yield - 750 gpm with 80-ft drawdown
21aba1	4,864	-	16	-	-	-	-	-	30	I	-	
21aba2	4,865	-	16	-	P	-	-	-	30	I	-	
23caa1	5,005	185	20	-	P	-	-	-	75	I	1953	
23cac1	4,970	247	18	-	P	-	37.44	9-26-68	100	I	1962	
26cba1	4,915	219	16	80	P	Qal	-	-	60	I	1961	Log; yield - 1,200 gpm with 160-ft drawdown
27ccb1	4,860	68	10	30	P	Qal	31.77	9-25-68	40	I	1961	Log; yield - 325 gpm with 60-ft drawdown
27ddb1	4,895	177	18	97	P	Qal	44.25	12- 2-68	60	P	1959	Log; yield - 300 gpm with 108-ft drawdown; city of Downey supply; CA

Table 4. Records of wells. (Continued)

Well No.	Land-Surface altitude (feet)	Depth of well (feet)	Casing		Well finish	Aquifer	Water level		Pump H.P.	Use of water	Date of well completion	Remarks
			Diameter (inches)	Depth (feet)			Depth (feet)	Date measured				
10S-37E-28abd1	4,855	237	16	42	P	Qal,Tsl?	33.36	9-27-68	75	I	1965	Log; yield - 1,200 gpm with 1-ft drawdown
28dac1	4,851	180	18	-	P	-	25.27	9-26-68	50	I	1953	
11S-37E-33caa1	4,822	228	16	75	P	Qal	-	-	75	I	1961	Log; yield - 1,350 gpm with 37-ft drawdown
33cda1	4,808	162	16	50	P	Qal	48.88	9-25-68	75	I	1959	Log; yield - 780 gpm with 30-ft drawdown
34dcd1	4,860	150	8	-	-	-	114.40	10-23-68	-	H	-	
12S-36E-14add1	4,990	150	6	135	P	Qal	109.96	10-24-68	-	U	1955	Log
12S-37E- 3daa1	4,775	-	12	-	-	-	-	-	15	I	-	
4bad1	4,802	208	16	60	P	Qal	-	-	100	I	1967	Log; yield - 1,000 gpm with 180-ft drawdown
5dcc1	4,750	-	-	-	-	-	28.18	9-24-68	50	I	-	
10bca1	4,808	225	16	59	P	Qal	18.74	9-24-68	75	I	1966	Log; yield - 700 gpm with 144-ft drawdown

from those springs is included in the river gain between miscellaneous measurement sites 7 and 8 and site 9 (fig. 9). On October 23, 1968, the gain in river flow in that reach, due wholly to ground–water discharge, was about 66 cfs (cubic feet per second). It was about 76 cfs in December 1968.

The major hot springs in the basin are Downata and Lava Hot Springs. Downata Hot Spring, a recreational site, is located in the SW¼ sec. 12, T. 12 S., R. 37 E. Twiss (1939, p. 20) stated that the spring has a constant flow of about 2 cfs, and postulated that the water obtains its heat from depth, percolating almost 2,500 feet into the Salt Lake Formation before it returns to the surface. Lava Hot Springs includes a number of hot springs in secs. 21 and 22, T. 9 S., R. 38 E., whose water is used at a recreational site and health spa. Stearns and others (1938, p. 171) discussed these springs in some detail and estimated their total flow at about 3 cfs. Chemical analyses of water from a number of the springs mentioned above are included in table 3.

Surface Water

There are four continuous–record gaging stations measuring stream discharge in the basin—three on the Portneuf River and one on Marsh Creek. The locations of these stations and the basin drainage system are shown in figure 9. Also shown is the location of the gaging station on the Portneuf River at Pocatello which, although outside the area studied, produces a record that is important to understanding the hydrology of the basin. Historic data are included in boxes near the location of the long–term record stations shown. Two stations, Portneuf River near Pebble and Portneuf River at Lava Hot Springs, were installed in the fall of 1968; therefore, these short records did not provide an adequate base from which meaningful streamflow characteristics could be derived.

Figure 10 shows annual and monthly mean discharges at three long–term gaging stations. The period 1955–68 was used as a basis for comparison because that is the total period of record for the station at McCammon. Because the records were not adjusted for irrigation diversions or reservoir storage, the discharges as shown are actual. The graphs of annual mean discharges at the comparative stations stay somewhat parallel to one another. Variation in magnitude of the annual mean discharges is largely caused by climatic changes. However, correlation of monthly mean discharges between stations is quite poor, especially during the summer period of June through September when the discharge at Pocatello falls appreciably below the discharge at Topaz, largely because of irrigation diversions from the Portneuf River below the Topaz gaging station.

Figure 11 shows flow–duration curves for the three long–term record stations. The curves, as compiled, show the long–period distribution of discharge without regard to the chronological sequence of discharge. The curves obscure the effects of years of high or low discharge as well as seasonal variations within the year. Because the discharge records used

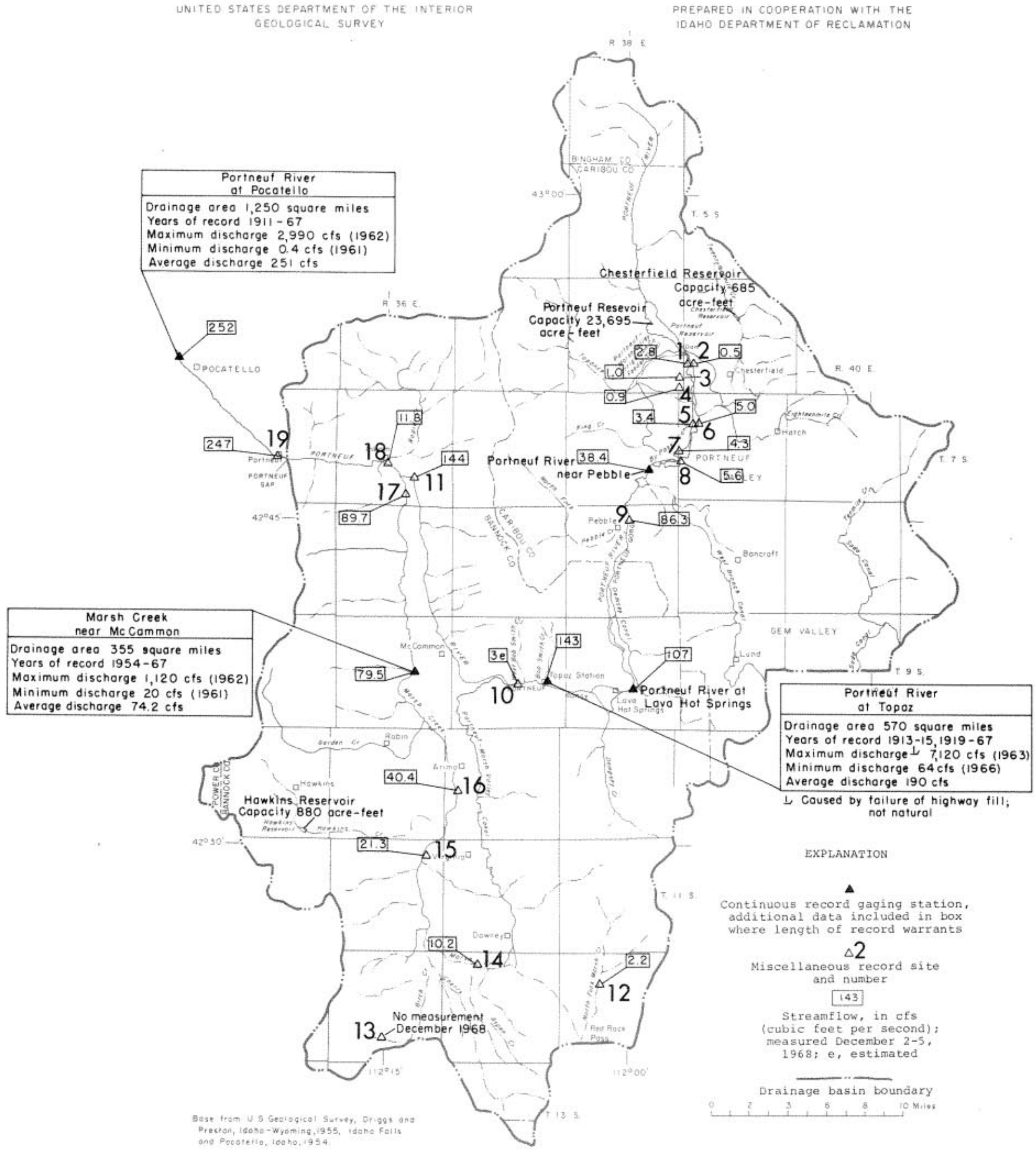

FIGURE 9.-- Map of the stream drainage system, location of measuring sites, and selected stream discharge data, Portneuf River basin, Idaho.

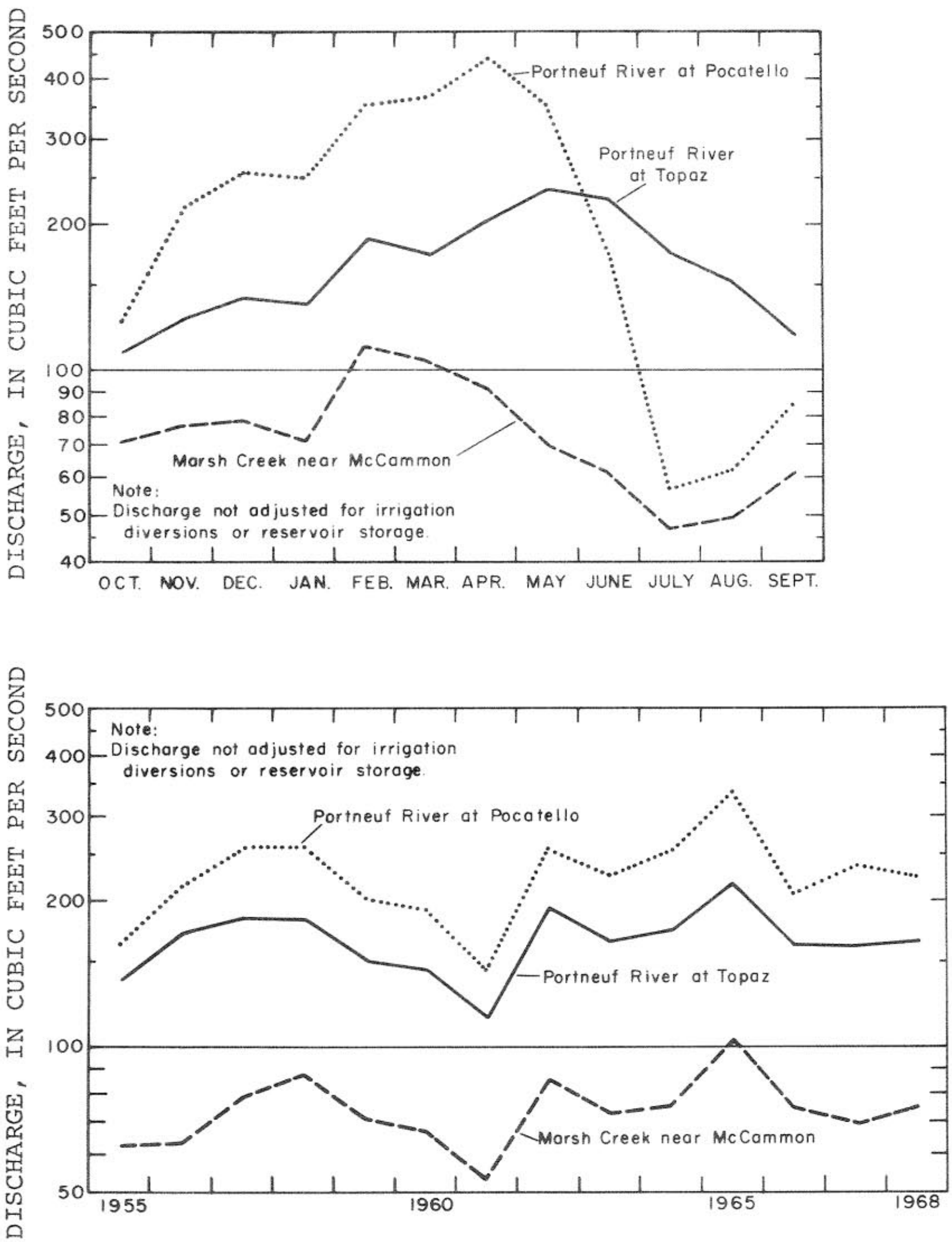

FIGURE 10.-- Annual and monthly mean discharges at selected gaging stations for the period 1955-68.

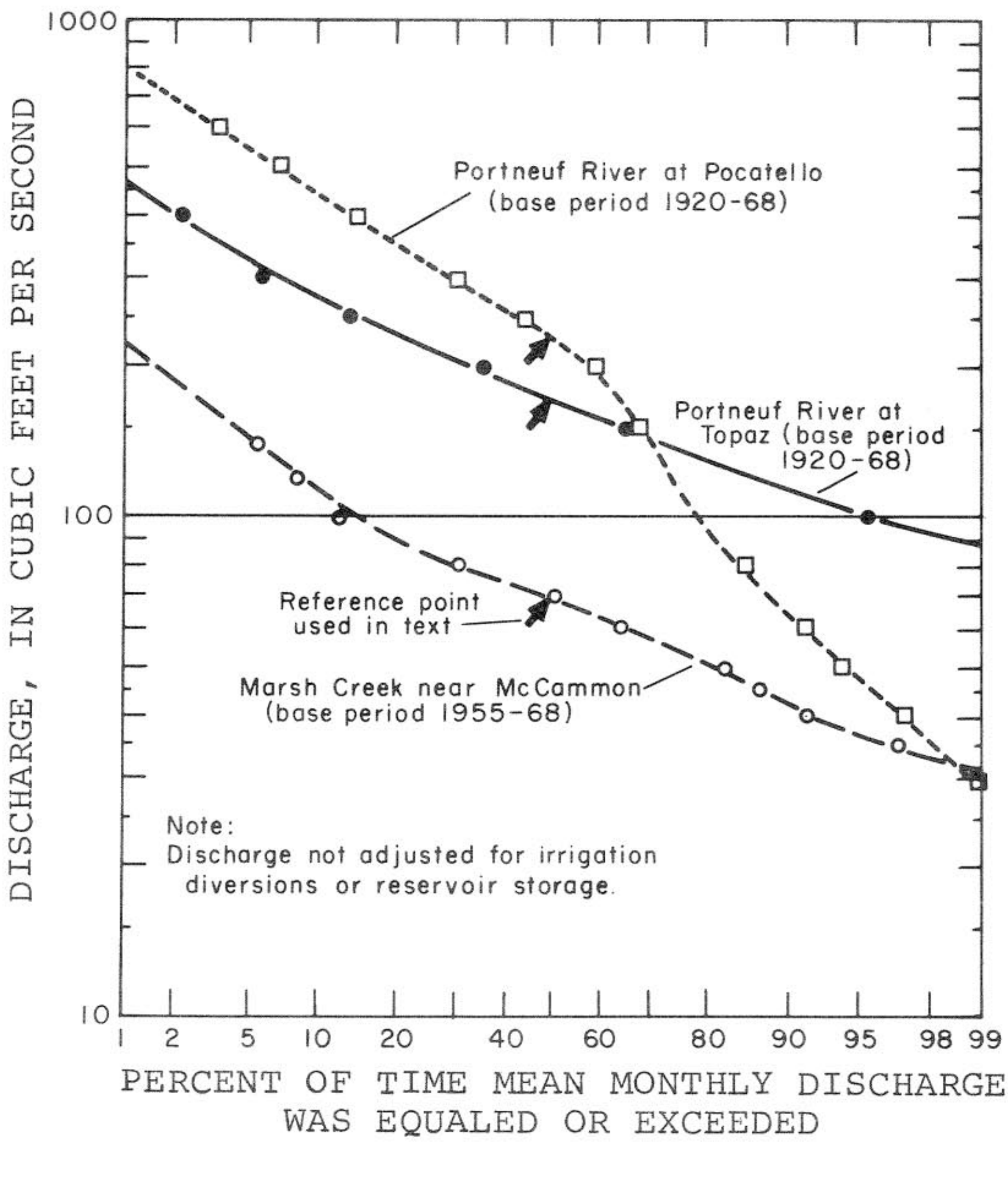

FIGURE 11.-- Flow duration curves for selected gaging stations in the Portneuf River basin, Idaho. (Based on mean monthly discharges).

to compile the curves have not been adjusted for diversions or reservoir storage, the curves reflect discharge conditions under past levels of streamflow and irrigation development. The curves indicate that 50 percent of the time, the mean monthly discharge at Topaz, McCammon, and Pocatello can be expected to equal or exceed 170, 69, and 228 cfs, respectively. The decline in the curve for Pocatello below 220 cfs is due primarily to irrigation diversions upstream.

The curves shown in figures 12, 13, 14 represent characteristics of flow of the Portneuf River at Topaz during the irrigation season, May 1 to September 30, only. The curves are based on the streamflow record for the period 1913–15, 1920–68, and are applicable so long as hydrologic conditions upstream from the Topaz station are not altered appreciably.

Figure 12 is a flow–duration curve of the mean daily discharge for the irrigation season. It may be used to determine the chance that a specified mean daily flow would be exceeded during that period. For example, the curve shows that for the period of record a mean daily flow of 200 cfs (cubic feet per second) has been exceeded 54 percent of the time during the irrigation season.

The low–flow frequency curves shown in figure 13 and the high–flow frequency curves in figure 14 were computed using the log–Pearson type III procedure whereby logarithms of the flow data are used to determine the Pearson type III cumulative density curve that best fits the data. Figure 13 is useful to determine the chance that the low–flow during a period of time will be less than a given mean discharge. For example, a mean discharge of 100 cfs for any 30–day period of low flow may be expected to occur once in about 7.2 years, and that the same mean discharge during a 1–day period may be expected to occur once in about 3.3 years.

Figure 14 indicates the chance that the high flow for a period of time will be greater than a given mean discharge. Thus, a high–flow mean discharge of 500 cfs for a 60–day period can be expected to occur once in about 45 years, and a 1–day mean discharge of 500 cfs may be expected to occur once in about 4.5 years.

During this study 19 miscellaneous stream–gaging sites were measured at different times to establish a basis for a better understanding of the stream system in the basin. Figure 9 shows the locations of these sites. Instantaneous discharge measurements taken at the miscellaneous sites in December 1968 and recorder station measurements for the same period are shown in small boxes near each site in the figure. The discharges measured during that period are believed to represent base–flow conditions in the basin. Relative gains in flow in different reaches of the streams are shown by these measurements. For example, the gain in discharge of the Portneuf River between sites 7 and 8 and gaging station Portneuf River near Pebble was 38.4 cfs minus 4.3 cfs and 5.6 cfs or 28.5 cfs. Similarly, the gain in

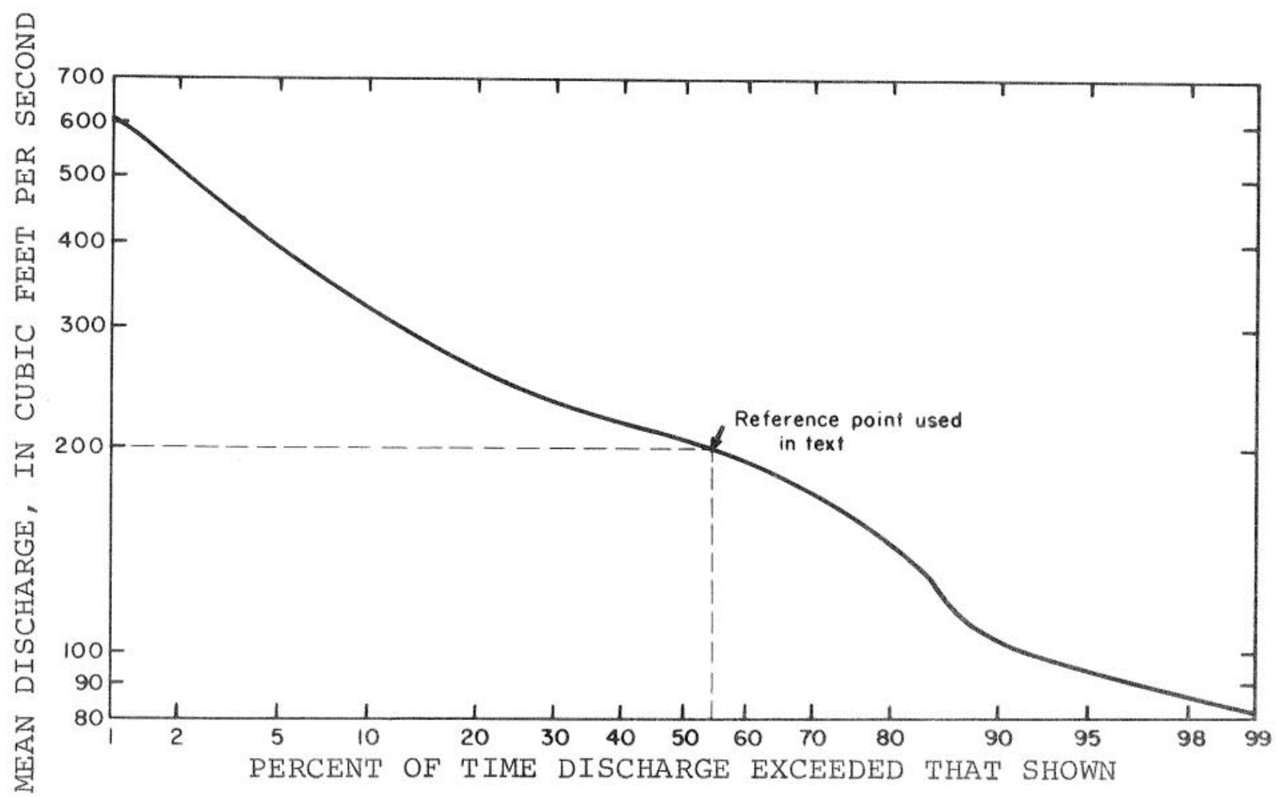

FIGURE 12.-- Flow-duration curve of daily flow for Portneuf River at Topaz, during irrigation season (May 1 to September 30).

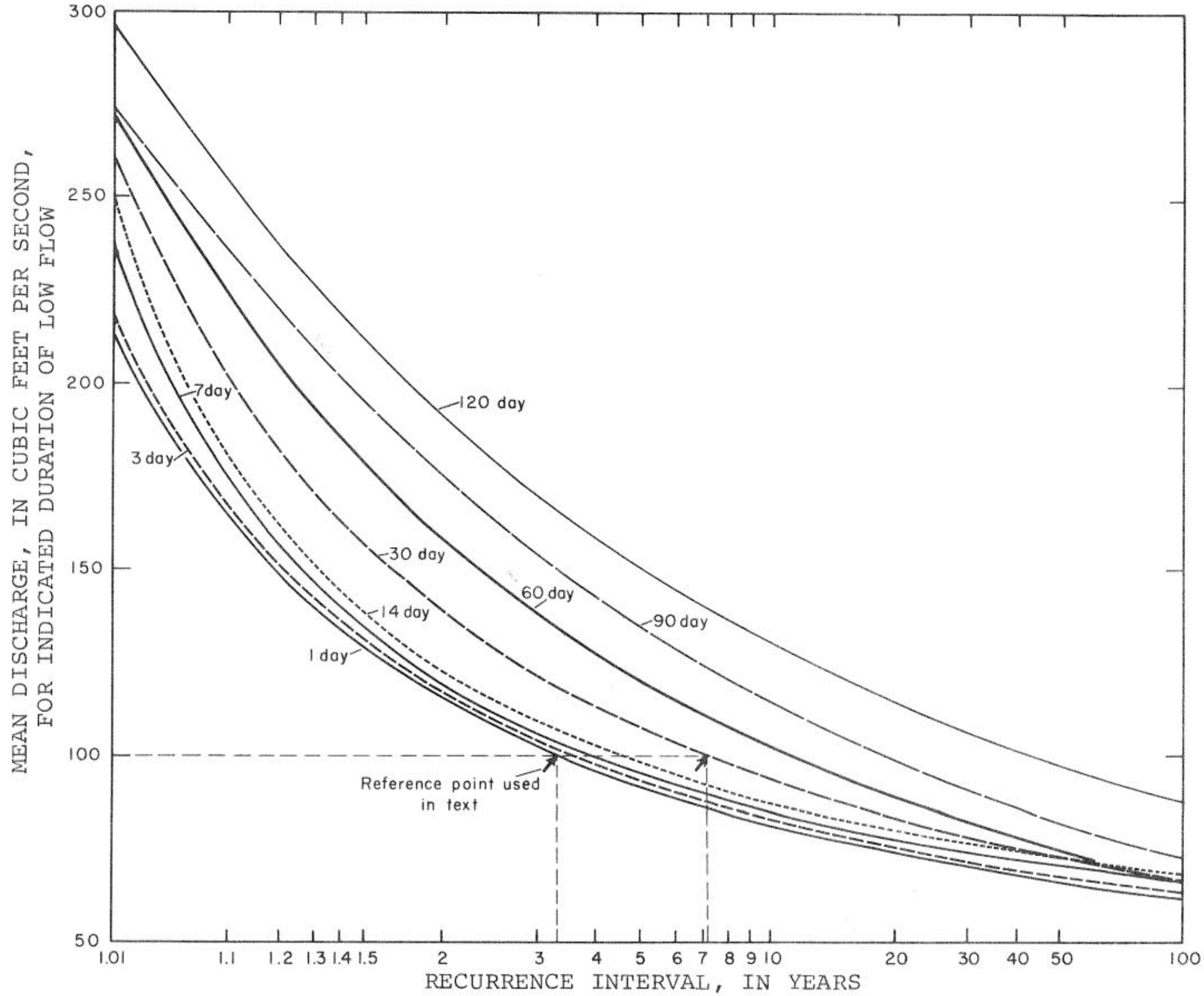

FIGURE 13.-- Low-flow frequency curves for Portneuf River at Topaz, during irrigation season (May 1 to September 30).

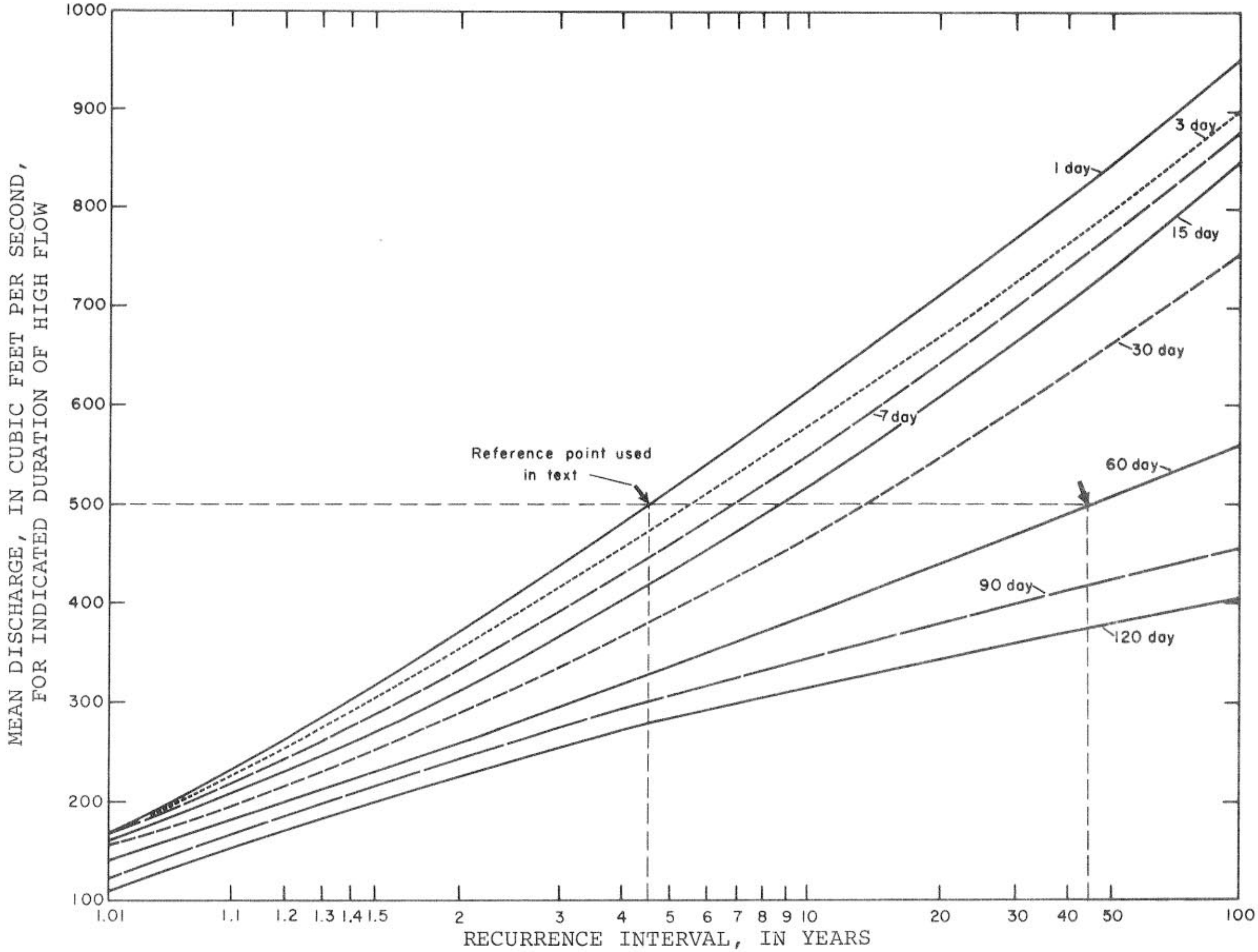

FIGURE 14.-- High-flow frequency curves for Portneuf River at Topaz, during irrigation season (May 1 to September 30).

discharge between gaging station Portneuf River near Pebble and site 9 is 47.9 cfs. The total gain within the two reaches is about 76 cfs, which can be attributed wholly to ground-water discharge. Other stream reaches in the system can be evaluated using similar computations.

An interesting and somewhat puzzling discrepancy occurs between the flow at the Pocatello gaging station and the combined flows of the Portneuf River at Topaz and Marsh Creek at McCammon. The average annual discharge at Topaz plus McCammon for the period 1955–68 is 240 cfs; whereas, the discharge at Pocatello for the same period is 228 cfs, an indicated average annual loss of 12 cfs in the reach. According to records of Water District 17, a yearly average of 57 cfs is diverted to the Portneuf-Marsh Valley Canal from the Portneuf River below Topaz. Assuming that 35 percent, or 20 cfs is used consumptively, then the adjusted apparent discrepancy in flows between the sites would be a gain of about 8 cfs. But, there are about 325 square miles of drainage basin contributing runoff to the river between the Topaz-McCammon and the Pocatello gaging stations. Two hundred and thirty-five square miles is above Portneuf Gap and within the basin of study, and the remaining 90 square miles is between the gap and Pocatello. Again, assuming that the unit runoff from the 325 square mile part of the drainage basin is similar to the unit runoff from that part of the basin above Topaz (0.292 cfs per square mile), then about 95 cfs (325 times 0.292) additional discharge should be gained between the above stations. This amounts to an apparent loss of 87 cfs (95 minus 8) or about 63,000 acre-feet per year somewhere between the Topaz-McCammon stations and the Pocatello station. The most obvious way for this loss to occur is as ground-water underflow past the Pocatello gage. Whether the bulk of this loss occurs above or below the Portneuf Gap is unknown.

Preliminary interpretation of sparse ground-water data shows that the water table in the vicinity of Portneuf Gap is about 30 to 35 feet below the level of the Portneuf River through the gap. Using a topographic map showing 10-foot contour intervals for altitude control, the water level in the fall of 1968 in well 7S-35E-23caa1 (fig. 7) was determined to be about 30 feet below the nearby river level. Similarly, the water level in well 7S-35E-21dad1, just west of the gap and beyond the basin boundary, was about 35 feet below river level. Also, the water level in wells at the Idaho Portland Cement Company at Inkom are reportedly below river level. It seems, therefore, that the Portneuf River is perched above the water table, at least in the reach from Inkom to Portneuf Gap and some distance beyond. Thus, it is inferred that a potential exists for channel leakage to occur in the lower reaches of the Portneuf River accounting for at least part of the apparent 87 cfs loss. More accurate altitudes and additional hydrologic data in this vicinity are needed to confirm the perched river condition.

Floods

With few notable exceptions, floods have caused little damage in the Portneuf River basin. In February 1962, however, a rare combination of circumstances resulted in a flood that caused severe damage, particularly in the towns of Bancroft and Lava Hot Springs. A description of that flood in the Portneuf River basin and in southern Idaho and northeastern Nevada is given in a report by Thomas and Lamke (1962).

Figure 15 is a flood-frequency curve for the Portneuf River at Topaz computed by the log Pearson type III method. Interpretation of the curve is indicated by the note referring to the point where the 10-year line crosses the curve on the graph. The relatively flat, left-hand segment of the curve represents annual peak discharges that may be expected to occur as a result of normal snowmelt runoff conditions above Topaz. The steep, right-hand segment of the curve is defined by floods that occurred during unusual winter conditions when frozen ground, rainfall, and warm temperatures resulted in excessive amounts of overland runoff. Many more years of record are needed to define better the right-hand part of the curve.

A knowledge of the magnitude and frequency of floods that may be expected to occur is essential for the design of bridges, culverts, dams, or other structures that may be affected by floods, and for flood-plain development.

QUALITY OF WATER

Analyses of 10 ground-water samples collected as a part of this study and numerous other analyses of both surface and ground waters made prior to this study are listed in table 3. A selected number of these analyses are depicted as patterns (Stiff, 1951) and are plotted in figure 16 near their points of collection. Dissolved-mineral concentrations are shown by the patterns in milliequivalents per liter (me/l). A milliequivalent per liter is one one-thousandth of a unit chemical combining weight of a constituent in a liter of water, and it may be obtained by dividing the concentration of the constituent in milligrams per liter by the chemical combining weight of the constituent. The patterns provide a visual method for rapidly determining similarities or dissimilarities in the chemical character of water samples collected at different places or times.

Examination of the water-analysis data in table 3 and figure 16 shows that the predominant water in the basin is of the calcium bicarbonate type. Sodium bicarbonate water occurs in the Lava Hot Springs and in flowing well 10S-37E-7cbc1, which probably is representative of the other warm-water flowing wells listed in table 2. The significance of the predominance of sodium in the warm and hot waters is not known, especially as sodium is not prevalent in the Downata Hot Spring water. Downata water differs further, for despite its elevated temperature (48° C), it is among the least mineralized waters in the basin.

Water in well 9S-40E-4cdd1 is of the magnesium bicarbonate type. Magnesium bicarbonate water also seems to prevail east of Soda Spring Hills in the vicinity of Soda

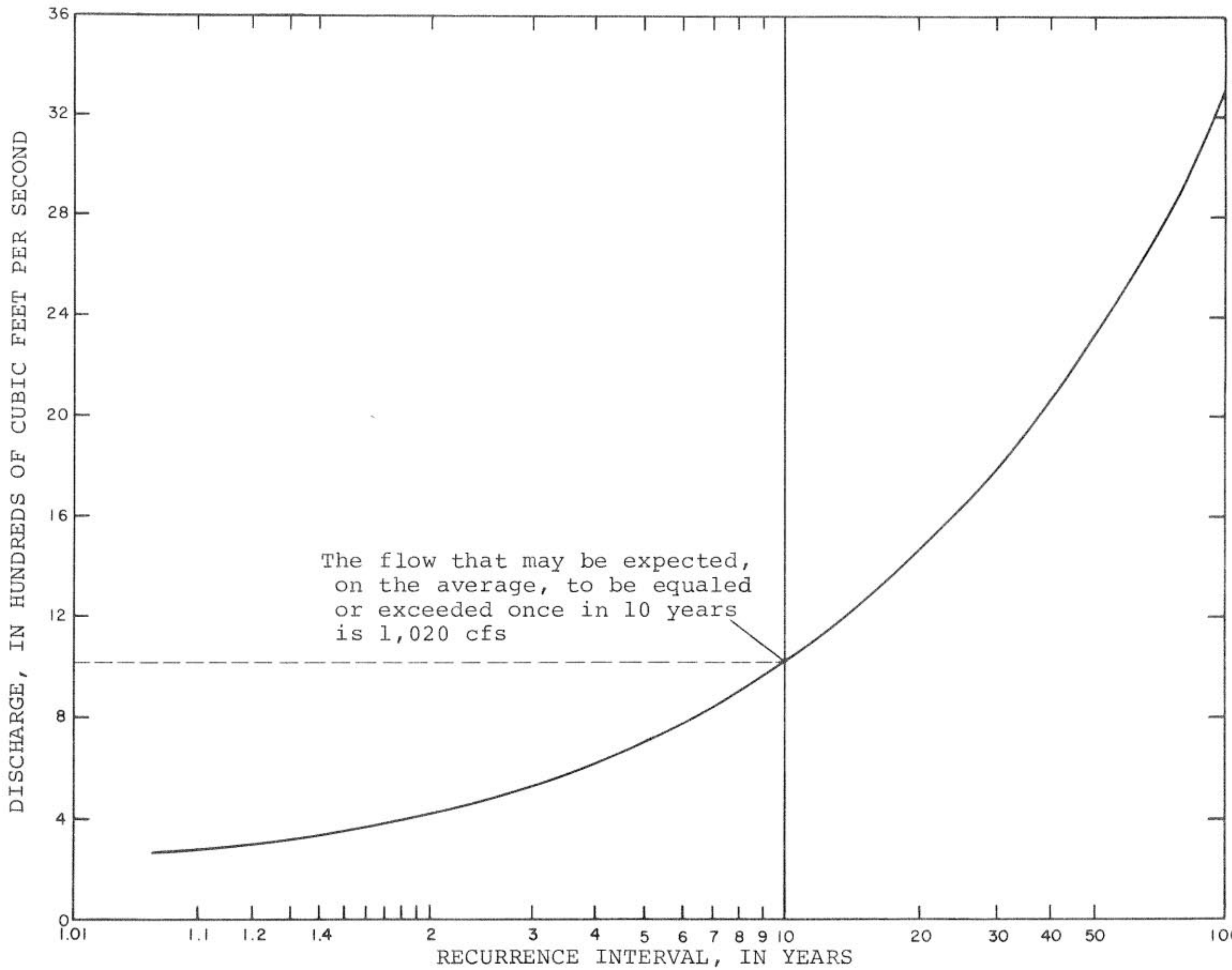

FIGURE 15.-- Magnitude and frequency of floods on the Portneuf River at Topaz, Idaho.

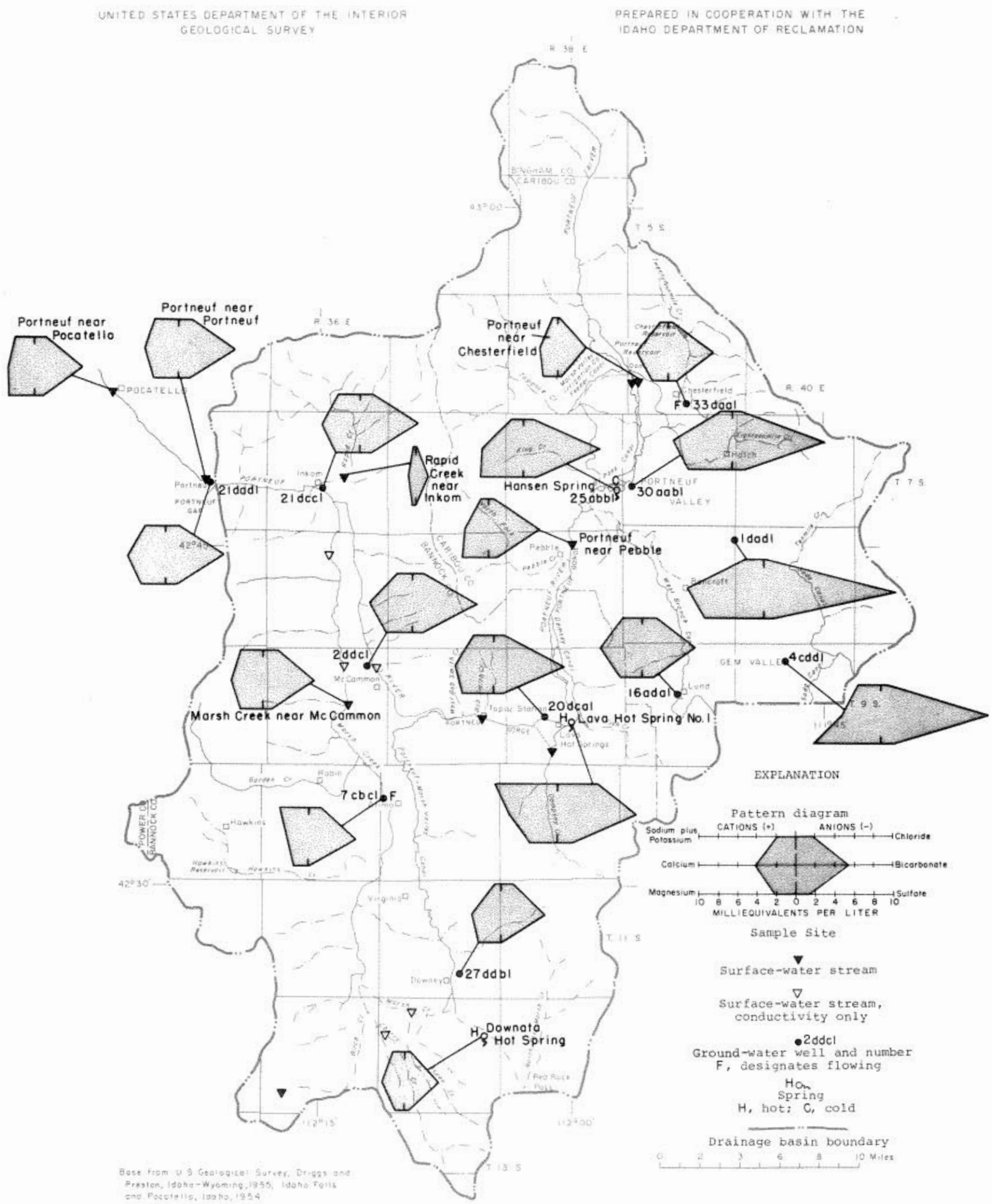

FIGURE 16.-- Chemical characteristics of water from selected wells, springs, and streams, and location of sample collection sites.

Creek and in central Gem Valley, south of the ground–water divide (N. P. Dion, Oral commun., 1969).

The value of pattern comparisons in deciphering ground–water flow is shown by the patterns for wells 7S–39E–30aab1, 8S–39E–1dad1, and 9S–40E–4cdd1. Water in these wells is from the basalt aquifer and, except for Lava Hot Springs, is more mineralized than any of the other waters shown in figure 16. In accordance with the statements on direction of ground–water flow on page 18, the analyses indicate that the water apparently moves downvalley to the discharge point at the Hansen spring (NW¼NW¼NE¼ sec. 25, T. 7 S., R. 38 E.). The water at the spring is less mineralized, probably having been mixed with water from the alluvial aquifer in the northern part of the valley. The mixture at the spring results in a magnesium calcium bicarbonate type water. Similar water, but of lesser mineralization, was found upon analysis of water from the Portneuf River near Pebble. The lower level of mineralization at this point is caused by dilution of the ground–water discharge with reservoir outflow. The ground–water similarities continue on downgradient in wells 9S–38E–20dca1 and 9S–36E–2ddc1 and beyond.

The surface–water analyses shown in table 3 and in figure 16 represent water samples collected at a particular time; they should not be considered representative of all streamflow past the sampling sites shown. Time and volume of discharge must be taken into account when sampling a stream. For example, the analysis of Rapid Creek near Inkom is very low in dissolved solids largely because the sample was taken in April when snowmelt accounted for most of the discharge. Had the sample been taken during a period of base flow, the concentration of dissolved solids would have been greater.

The analyses listed in table 3 indicate that for human consumption no chemically "bad" water has been detected in any of the wells, springs, or streams sampled. The dissolved solids in some of the waters exceed the 500 mg/l limit recommended for use by the U.S. Public Health Service (1962) but the excess is not critical. Some of the waters have pH values of more than 8.0 and may be considered as slightly alkaline, but they are, nevertheless, potable. Most of the waters listed are hard. Trace–element studies have not been made, but there is presently no reason to suspect that deleterious concentrations of trace constituents occur.

Figure 17 (U.S. Salinity Laboratory Staff, 1954) shows the suitability of the different waters for irrigation use. The samples are numbered as shown in the "salinity diagram number" column in table 3. The classifications on the diagram are based on specific conductance and on SAR (sodium–adsorption ratio). $SAR = Na^{+} \frac{Ca^{++} + Mg^{++}}{2}$, in which the concentrations are expressed in milliequivalents per liter. Values for 24 samples of water are plotted on the diagram as shown. All samples plotted fall within the Sl, low sodium water, classification. Sl water can be used on most soils with little danger of development of harmful levels of exchangeable sodium, except perhaps when used for sodium–sensitive crops (Wilcox, 1955, p. 10).

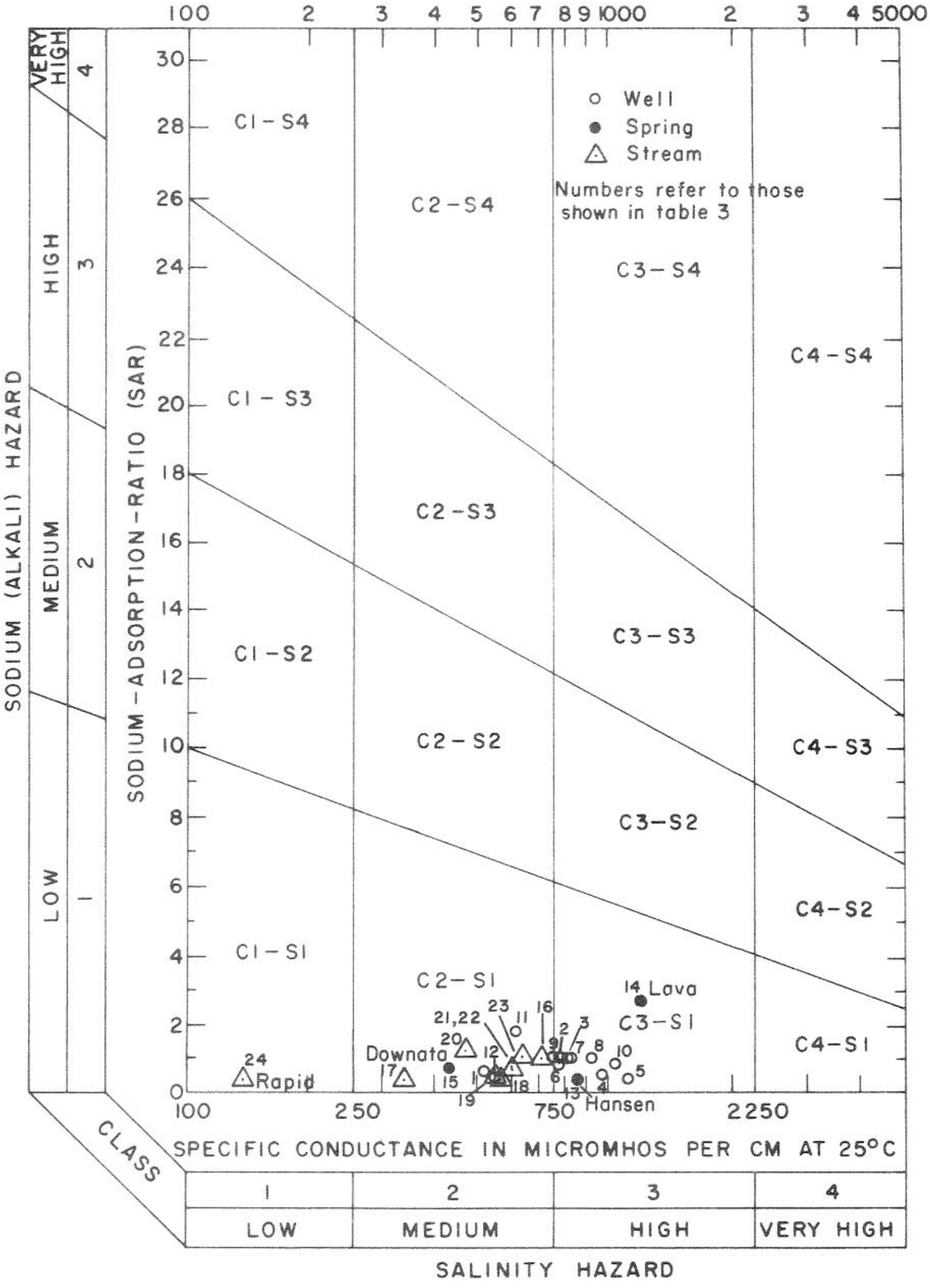

FIGURE 17.-- Diagram for the classification of irrigation waters.

Most of the samples plotted fall within the C2 and C3 classifications, medium and high salinity waters, respectively. C2 water can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most places without special practices of salinity control. C3 water should not be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required, and only plants with good salt tolerance should be grown.

USE OF WATER

The major use of water in the basin is for irrigation, followed by municipal, industrial, domestic, and stock use; but not necessarily in that order. There are roughly 33,500 acres of irrigated farm land, six municipalities that have public water supplies, and one industrial plant that uses an appreciable amount of water. No estimate was made during this study of the use of water by the farm population or by livestock.

Ground Water Irrigation

An attempt was made to canvass all the irrigation wells in the basin. Table 4 contains data on the 148 wells visited for this study. Eighty six of these wells are used for irrigation purposes; the remainder are used either for domestic, stock, industrial, or public supply purposes, or are unused. The wells in the upper valley above Topaz range in depth from 32 to 640 feet and have a median depth of 150 feet below land surface. The wells in the lower valley below Topaz range in depth from 32 to 585 feet and have a median depth of 168 feet below land surface.

Most of the well owners visited were asked to estimate the amount of ground water pumped for irrigation and the acreage on which ground water was used. The geographic location of the acreage irrigated by ground water is shown in figure 18, and estimates of total pumpage are given below. For convenience, the estimates of pumpage are totalled separately for those lands upstream from Topaz and those lands downstream from Topaz. The estimates are approximations and the land owners who also have surface-water rights may interchange the use of surface and ground water on those lands that are shown as "irrigated by ground water" in figure 18. That is, during a year of abundant streamflow, they may pump less ground water than they would during a year of deficient streamflow.

Above Topaz

An estimated 9,500 acres above Topaz is irrigated in whole or in part with ground water. The total amount of water pumped during the irrigation season is about 20,800

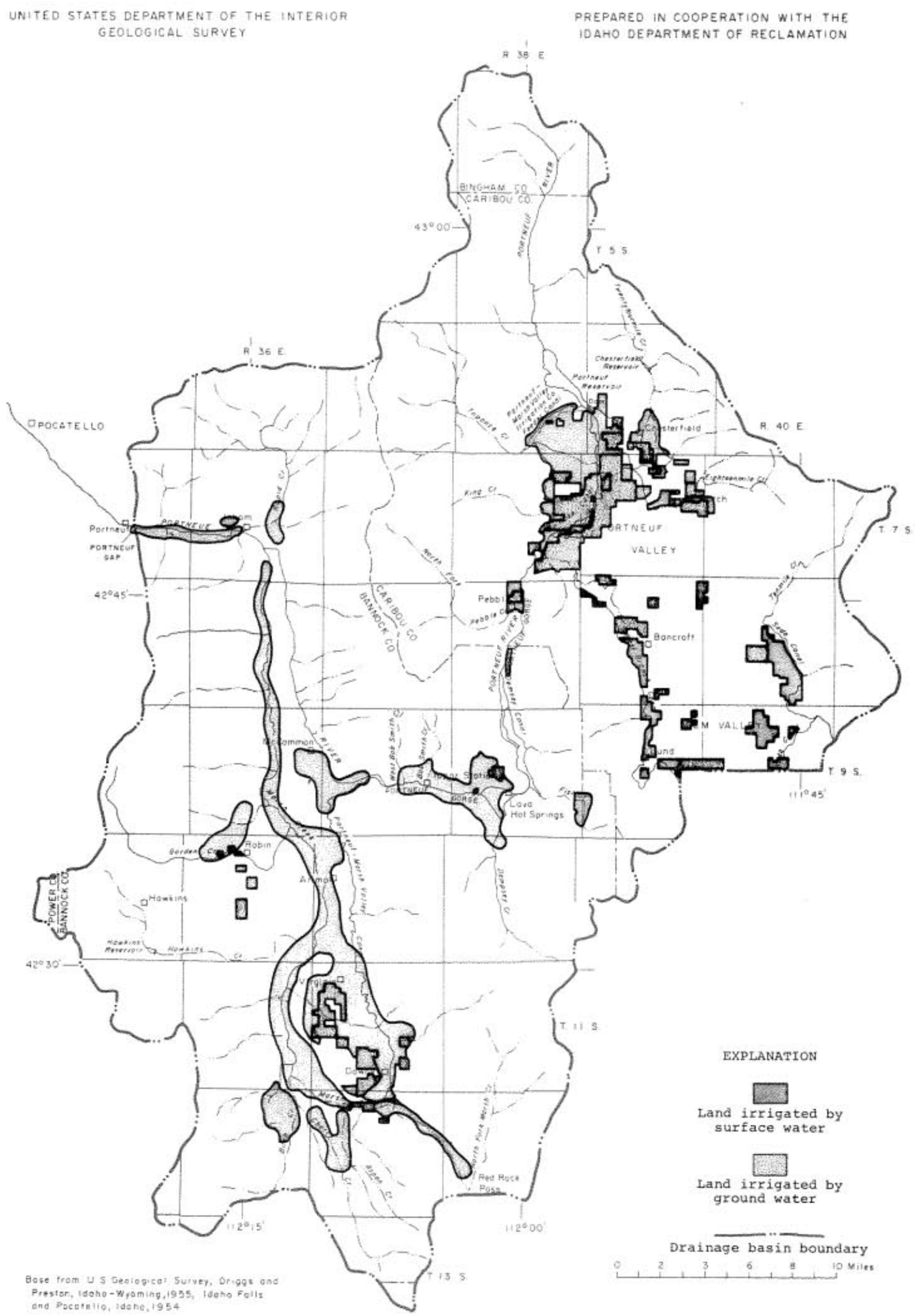

FIGURE 18.-- Map of Portneuf River basin showing generalized extent of irrigated lands.

acre-feet. This amounts to about 2.2 acre-feet pumped per acre. It is estimated, using the method of Jensen and Criddle (1952) and the 1964 Census of Agriculture Preliminary Reports for Bannock and Caribou Counties (U.S. Bureau of the Census, 1966), that the average consumptive crop use in the basin is 1.4 acre-feet per acre per irrigation season, and that the average consumptive irrigation requirement (consumptive crop use minus seasonal precipitation) is 1.1 acre-feet per acre. Therefore, about 50 percent of the total pumpage is consumed by crops; a large part of the remainder seeps into the subsurface to return to the aquifers. It is not known how much, if any, of the excess pumpage runs directly overland to the streams. Net pumpage for irrigation above Topaz is estimated to be 10,400 acre-feet per season.

Below Topaz

An estimated 4,000 acres below Topaz is irrigated in whole or in part with ground water. The total amount of water pumped per irrigation season is about 9,200 acre-feet, or about 2.3 acre-feet per acre. Because pumpage data were lacking in this part of the basin, the average amount of water pumped per acre irrigated was derived from estimates obtained from 10 farms in Marsh Creek valley. The average consumptive use and the consumptive irrigation requirement are similar to those above Topaz, thus an estimated 48 percent of the pumpage below Topaz is consumed by crops. Therefore, net pumpage below Topaz is about 4,400 acre-feet per season.

The total seasonal net pumpage for the entire basin is roughly 14,800 acre-feet and the total gross pumpage is roughly 30,000 acre-feet. The above pumpage figures are general seasonal estimates and will vary from year to year depending on climate and, if present trends of ground-water development continue, the pumpage will probably increase.

Surface-Water Irrigation

Of the approximate total of 33,500 acres of irrigated land in the basin, about 20,000 acres are irrigated solely with surface water. In addition, an unknown but probably small part of the 13,500 acres irrigated with ground water is also supplied partly with surface water. The scope of this reconnaissance did not include detailed mapping of the surface-water irrigated acreage, but the generalized location of surface-water irrigated lands as compiled largely by the U.S. Soil Conservation Service is shown in figure 18.

The major sources of the surface water are Portneuf River and Marsh Creek, their tributaries, and imported water from Bear River. Total reservoir storage capacity in the basin is about 25,2[illegible]0 acre-feet. The location and capacities of Portneuf, Hawkins, and Chesterfield Reservoirs, the only significant storage facilities in the basin, and of some of the latter canals are shown in figure 9.

Quantitative evaluation of the amount of water distributed by the surface–water irrigation system as it is presently established is difficult. There is a serious lack of (1) suitable daily distribution records, (2) gage–height readings in Portneuf Reservoir, (3) records of inflow to and outflow from the reservoir, and (4) measuring devices for obtaining inflow and outflow records. Further, the gaging stations at the heads of the canals below Topaz are poorly placed and their records are affected by adverse conditions in the canals. Woodward (1956, p. 18) noted these deficiencies, and since that report a Parshall flume was constructed in the outlet channel below the Portneuf Reservoir to obtain better outflow records.

Despite the lack of data an attempt was made to approximate the amount of surface water used for irrigation in the basin. The Watermaster's Report for Water District 17, governing the distribution of Portneuf River water, shows that for the period June 1 to September 15, 1967, about 77,300 acre–feet of water was distributed from the Portneuf River and other streams in the district (Marsh Creek and its tributaries are not part of District 17)—30,400 acre–feet was distributed above Topaz and 46,900 acre–feet was distributed below Topaz. Any diversions prior to June 1 or later than September 15 were not recorded. The average discharge of the Portneuf River at Topaz for the period 1920–68 between June 1 and September 15 was about 41,500 acre–feet. The average discharge for the same period in 1967 was about 1,000 acre–feet more than the long–term average; therefore, the quantity of water available for distribution in 1967 was somewhat above normal.

In addition, estimates were obtained for distribution from the Bear River system to the West Branch and Soda Canals. Flow in those canals totalled about 14,000 acre–feet. Thus, the amount of surface water distributed from all major sources of water is probably at least 91,300 acre–feet per irrigation season. Assuming that the total irrigated land is 20,000 acres, then about 4.6 acre–feet of water per acre is distributed, but that figure is deceptive for there is probably at least 30 percent loss in the distribution canals. Perhaps, on the average, about 3 acre–feet per acre is available at the farm headgates.

The above calculations are very rough approximations. Because distribution data are lacking, better determinations cannot be made at this time; however, the approximations do give an idea as to the magnitude of the surface–water irrigation system and the amount of water used.

Municipal and Industrial Supplies

Table 5 lists selected data on six municipal supply systems. The annual–use data in the table were obtained from the University of Idaho Water Resources Research Institute (1968, p. 49[illegible]–491). The other data were acquired from persons directly or indirectly responsible for the water supply in each municipality.

Table 5. Selected data on municipal water supplies in the Portneuf River basin.

Municipality	Population	Source of supply	Annual use (acre-feet)	Storage	Approximate number of customers	Treatment	Sewage facilities	Remarks
Arimo	303	2 springs, 1 well	112.0	1 reservoir - 45,000 gallons	100-110	None	Septic tanks	Meters removed because sand clogged gears
Bancroft	495	2 springs, 2 wells (1 well on standby)	224.1	1 reservoir - 16,000 gallons	100	Occasional chlorination when needed	Lagoon system	
Downey	726	7 springs, 2 wells	392.3	2 reservoirs - 1) 125,000 gallons 2) 325,000 gallons	200	None	Spectic tanks	1 well used only for summer irrigation; meters sand clogged gears
Inkom	528	2 wells	201.7	1 reservoir - 92,000 gallons	147	None	Lagoon system	
McCammon	557	1 spring	358.8	1 reservoir - 300,000 gallon tank	180	None	Spectic tanks	
Lava Hot Springs	593	14 springs, 1 well (supplemental)	112.0	1 reservoir - 159,000 gallons	210	Occasional chlorination when needed	Lagoon system	1 new (1968) well not yet used; meters being installed

The Idaho Portland Cement Company plant at Inkom is the only large industrial user of water in the basin. The plant has two main wells, at least one of which is pumped at all times throughout the year. Total annual pumpage is about 470 acre–feet (153 million gallons). Of that, about 40 acre–feet (13 million gallons) is used consumptively in kilns. Most of the remainder circulates through the plant and is discharged into the river.

INTERRELATION OF SURFACE AND GROUND WATER AND THE EFFECTS OF PUMPING WELLS

Since about 1951, the quantity of ground water pumped for irrigation has grown from an almost negligible amount to about 30,000 acre–feet per irrigation season. This is about one third as much as the total quantity of surface water used for irrigation in the basin. The use of ground water continues to grow as more and more farm owners are turning to irrigation from ground–water and giving up dry farming practices. Also, they are using increasing amounts of ground water to replace or supplement unpredictable surface water supplies. As a result of this increased use of ground water, questions have arisen concerning the effects of ground water withdrawals on the flow of streams and how these effects can be appraised.

During this study, attempts were made through use of historical records to determine if any changes had occurred in streamflow as a result of ground–water withdrawals in the upper valley. Several means of identifying possible changes were tried, but in nearly all cases the data and records available were too meager or too short to allow meaningful analysis.

Comparison of the average annual discharge of the Portneuf River at Topaz with precipitation records at Pocatello and Grace revealed no definite indication of a reduction in flow that might be caused by ground water pumping in the upper valley. Changes in the storage capacity and operational procedures for Portneuf Reservoir, coupled with an attendant change in the irrigation distribution pattern also precluded use of most average flow data as an indication of change in the outflow from the upper valley.

An attempt was made to measure possible effects of pumping on streamflow by monitoring the change in ground–water discharge to the Portneuf River between miscellaneous measurement sites 7 and 8, and site 9 (fig. 9). However, repeated monitoring of these sites showed no conclusive indication of reduction of ground–water discharge attributable to pumping. As might be expected, there are many factors other than pumping that influence the interchange between ground water and surface water in the upper basin. Some of the more important are increased evapotranspiration by growing crops, changing locations and timing of recharge from surface–water irrigation applications, and the very slow adjustment of ground–water levels to withdrawals from an aquifer with large storage capacity. The data collected from the monitoring suggest that if pumping has any effect upon the streamflow, the lag in ground–water level changes probably causes the effect to occur after the irrigation season when streamflow monitoring at the miscellaneous measurement sites is discontinued. Detailed records and measurement of these and other factors must be made over a period of at least one full year before any judgment may be made as to the potential effect of ground–water pumping upon streamflow.

RECOMMENDATIONS FOR FUTURE STUDIES

Although some quantitative data are contained in this report, they are based on a minimum time for analysis; and, as in all reconnaissance studies, the results can benefit by the collection of additional data. Thus, future work needed to make a comprehensive study would include elaboration on some of the topics described herein and the acquisition and interpretation of new data. Major items on which future work should focus are (1) a water budget, (2) hydrologic mapping, (3) hydrology of aquifers, (4) the irrigation system, (5) geologic mapping, and (6) special problems.

Water Budget

A firm water budget would be helpful in making a quantitative evaluation of the water resources in the basin. The elements in a water budget are total inflow to and total outflow from the basin. Those elements must be balanced, taking into account changes in storage. Inflow includes precipitation on and underflow and importation into the basin. Outflow includes evapotranspiration within the basin, and exportation, streamflow and underflow out of the basin.

As part of the inflow determination, a precipitation map (fig. 3) was made during this study. It is based on the only precipitation data available to date. Refinement of the map can be accomplished only by establishing new precipitation stations. Rain gages placed at strategic sites in the mountains would help refine the present map, but long–term record sites –one in the upper and one in the lower valley– would help most in making any future map. These should be established as soon as possible.

Another part of the inflow determination is the underflow from the adjacent Blackfoot and Bear River basins, particularly at Tenmile Pass and at Soda Point. Underflow at Tenmile Pass is postulated for reasons mentioned previously. At least two hydrogeologic test wells would have to be constructed to evaluate the potential for and the amount of underflow. Geophysical profiles in conjunction with the test wells would be advisable to obtain maximum value from the drilling. One test well is needed at the basin boundary east of the pass and another at the crest of the pass. If water levels measured in the test wells showed that a continuous gradient did exist between the adjacent basins at that place, then a transmissivity value would be needed for the intervening aquifer. The transmissivity value could be determined by making pumping tests using the test wells. Knowing the width of the aquifer through the pass, the hydraulic gradient, and the transmissivity, a value for underflow through the pass could be calculated (Ferris and others, 1962, p. 73).

Determination of volumes of underflow into the basin near Soda Point would require a closely controlled water-table contour map to be made of the area extending from the pass at Soda Point and spreading out over the ground-water divide in Gem Valley. Additional water levels in wells and precise topographic leveling would be needed to draw the map and accurately locate the ground-water divide. A flow net of the area of interest could then be drawn to obtain a gradient and determine a width of flow. Transmissivity values could be determined using wells in the area. Given the three needed values, the above cited method could again be applied to calculate the amount of water being contributed to the Portneuf River Basin.

As stated above, the outflow elements include evapotranspiration, streamflow, and underflow out of the basin. Methods to estimate the evapotranspiration are available (Roseberg and others, 1938) and need not be elaborated on here. To determine the streamflow out of the basin, it would be necessary to establish a continuously recording surface-water gage in the Portneuf Gap. To determine the underflow through the gap and out of the basin, at least one and preferably two geohydrologic test wells should be drilled in the gap. Geophysical studies probably should be made to extend the test-hole information. The wells should be drilled to bedrock. The rate of underflow could then be determined as explained for Tenmile Pass. Also, the firmness of the budget would be enhanced by determining the hydrologic cross section at Pebble so that outflow from only the upper valley could be evaluated. The methods used previously also would apply here.

Water-Table Mapping

The water-table map (fig. 7) drawn for this study is not complete, but covers only areas of major ground-water pumping. Also, topographic control is lacking for better definition of the contours now drawn. The well canvass should be extended, and observation wells established in needed areas to complete contouring of the water-table throughout the entire basin. The canvass should make a particular effort to search out those wells measured by Stearns and others (1938) in 1928-29 so they can be included on the new map. Water-level measurements should then be made in the autumn so reasonable comparisons can be made of water-level changes occurring between the 1928-29 period and the time the later measurements were made. Also, water-level measurements made in the six observation wells established as a part of this study should be continued into the future so that long-term water-level trends can be established. As a part of the canvass, a representative number of springs also should be scheduled and their elevation determined.

Hydrology of Aquifers

Data on the hydraulic characteristics of the aquifers are now lacking. These characteristics are best determined by field pumping tests. Although the results obtained from pumping tests are approximations, they are useful in evaluating the performance of an aquifer. Transmissivity and storage coefficients may be computed, hydrologic boundaries located, and future effects of pumping predicted from data derived from such tests. The storage coefficient is defined as the volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface. The tests involve controlled pumping and measurement of water levels in the pumping well and in nearby observation wells, both before and during pumping and after pumping is stopped.

In some places, pumping tests to determine the hydraulic characteristics of the aquifers may not be practical. Estimates of transmissivity values may be obtainable by determining specific capacities of representative wells in the different aquifers. However, storage coefficients cannot be obtained in this manner.

In relation to hydrology, it is suggested that the miscellaneous stream measurements be continued at least through one annual cycle. If a comprehensive study is started, additional measurements of water levels in wells and of streamflow should be made as needed.

Irrigation System

A better means should be devised to obtain quantitative data from the present surface water irrigation system. Woodward (1956) pointed out some shortcomings in the recording of flow into and out of the Portneuf Reservoir. Hopefully, these shortcomings can be eliminated. A full quantitative study would include the acquisition and compilation of the following measurements:

Inflow to Portneuf Reservoir; outflow from Portneuf Reservoir; water-level fluctuations in Portneuf Reservoir; flow into main canals; diversions out of Topance, King, Pebble, Twentyfourmile, Eighteenmile, Dempsey, Fish, Bob Smith, Marsh, Birch, Hawkins, and Garden Creeks, Crystal Springs, and any other sources from which significant amounts of water are being diverted. Preferably the records on the Portneuf Reservoir should be obtained with continuously recording devices. Also, more complete records should be obtained on the flow in Soda and West Branch Canals which import water from the Bear River system.

Refined determination of the amount of ground water used for irrigation is needed. An attempt should be made to update records on the increased use of ground water for irrigation in the basin.

Geologic Mapping and Deep Test Drilling

The geologic map for this study was compiled from the work of previous studies made in the basin. Mapping in the Marsh Creek valley is almost completely lacking. At least reconnaissance geologic mapping should be completed if future hydrologic work is to be done in the basin. Also, geophysical work (p. 19) has shown the apparent occurrence of a structural trough that may contain sediments as much as 8,000 feet thick in central Portneuf and Gem Valleys. A number of deep geohydrologic test holes should be drilled to either prove or disprove the occurrence of such a structure, for this deep trough could constitute a valuable source of ground water.

Special Problems

Special problems that may arise will probably be related to infringement on water rights among the different irrigators in the basin. The interrelation between ground and surface water is a problem of that nature. One method of approach is suggested in this study on page 50. Some other method may be workable, such as an analog model which can be used to help describe the overall functioning of the natural system and the stresses imposed on it.

Interferences among pumping wells also may create special problems. Such problems can be evaluated through use of field pumping tests.

SUMMARY

The average annual total supply of water to the basin is slightly greater than 1.2 million acre–feet. Sources of supply are precipitation on the basin and postulated underflow from adjacent basins. Some water also is imported from the Bear River for irrigation.

An apparent 87 cfs (63,000 acre–feet per year) passes as underflow somewhere between the stream gaging stations Portneuf River at Topaz and Marsh Creek near McCammon, and the station Portneuf River at Pocatello. The actual average annual measured loss between those stations is 12 cfs. The lower reach of the Portneuf River, at least between Inkom and beyond Portneuf Gap, apparently is perched above the regional water table, thus facilitating the loss. But, it is not known how much of the 87 cfs occurs above the Portneuf Gap.

The major ground–water aquifers are the basalt and alluvium of Quaternary age and the Salt Lake Formation of Tertiary age. Ground–water wells in the basin range from 32 to

640 feet in depth. The median well depth is 150 feet below land surface in the upper valley and 168 feet in the lower valley.

General ground–water movement is from the uplands to the center of the valleys, and thence, downgradient in the direction of streamflow. Some movement may occur vertically upward through leaky confining strata where water–table aquifers are underlain by artesian aquifers.

Chemically the predominant water in the basin is of the calcium bicarbonate type. Sodium bicarbonate water occurs in the Lava Hot Springs and in some warm–water flowing wells near Arimo in Marsh Creek valley. The most highly mineralized water, excepting Lava Hot Springs, occurs in the basalt aquifer in the upper valley. The water seems to become less mineralized as it moves downgradient, presumably by dilution. Some of the waters used for irrigation are in the medium and high salinity classifications.

Approximately 91,300 acre–feet of surface water is diverted during an annual irrigation season to irrigate about 20,000 acres of land. This includes about 14,000 acre–feet imported from the Bear River. A total of about 30,000 acre–feet of ground water is pumped per season for irrigation, of which, about 20,800 acre–feet is pumped in the area upstream from Topaz to irrigate about 9,500 acres, and about 9,200 acre–feet is pumped downstream from Topaz to irrigate about 4,000 acres. The estimated average annual consumptive use of crops is about 1.4 acre–feet per acre per season, and the consumptive irrigation requirement is about 1.1 acre–feet per acre. Thus total net ground–water pumpage in the basin is roughly 14,800 acre–feet.

Since about 1951, ground–water pumpage for irrigation has grown from an almost negligible amount to an amount equal to about one third of the total quantity of surface water diverted and applied for irrigation. The trend is toward greater use of ground water. Ultimately, this trend might reduce streamflow, but data needed to estimate the time and the quantity of this reduction are not available. Direct measurement of seepage losses along selected stream segments during the pumping season may be useful if an attempt is made to evaluate possible losses in stream discharge resulting from ground–water withdrawals.

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UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
IDAHO DEPARTMENT OF RECLAMATION

Base from U.S. Geological Survey, Driggs and Preston, Idaho-Wyoming, 1955, Idaho Falls and Pocatello, Idaho, 1954.

SCALE 1:250 000
0 2 4 6 8 10 Miles
CONTOUR INTERVAL 200 FEET
100 FOOT SUPPLEMENTARY CONTOURS, DASHED
DATUM IS MEAN SEA LEVEL

FIGURE 1.--Index and topographic map of Portneuf River basin, Idaho.